LUMBER MANUFACTURE IN THE DOUGLAS FIR REGION

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DEDICATION

TO William B. Greeley in recognition of his interest, co-operation and support in the preparation of this work.

TABLE OF CONTENTS.

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

TABLE OF CONTENTS—Continued

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SCOPE AND PURPOSE OF THE BOOK

The purpose of this book is to present in convenient form data on the methods and costs of constructing and operating plants for the manufacture of lumber from Douglas fir in the region west of the Cascade Mountains in Oregon and Washington. Taken in connection with U. S. Department of Agriculture Bulletin No. 711, "Logging in the Douglas Fir Region," by William H. Gibbons, similar data is available on both the logging and manufacturing branches of the fir lumbering industry. The information is intended primarily for National Forest timber appraisers and other National Forest officers, for lumbermen not familiar with the manufacture of Douglas fir and for students of forestry; particular efforts have been made also to include information of value to mill architects and machinery manufacturers, as well as to the lumbermen themselves. The geographic limitations mentioned above should be kept in mind because most of the conclusions and figures are not applicable to lumber manufacture in other regions nor for other species of wood. *This is to be understood in all cases whether or not it is specified that the text applies only to conditions at fir mills.*

The particular information of costs and other specific data subject to fluctuations with time are all *as of* 1916 and are published now because earlier presentation was prevented by the War. It is realized, of course, that these notes are neither flawless nor altogether complete; but they are the best available even now and furnish a reliable basis for estimates of complete operations. The variety of conditions at the many different sizes and types of mills have rendered it necessary to make the text and some of the tables directly applicable only to the average mill; so care and judgment must be used in modfying the data to meet a specific case. Most of the data is applicable to mills cutting more than 50,000 board feet of lumber per day. No attempt has been made to cover the small mills because they are relatively unimportant from the standpoint of the proportion of the product which they manufacture. Electric mills have been featured throughout because it is believed that information on mills of this character will be in greater demand as time goes on.

In presenting the data an endeavor has been made to follow the natural course of the material through the various steps in the operation. This was done primarily to make the information accessible without the necessity of

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an alphabetical index and to bring the discussions of associated equipment and operations as close together as possible. There has been included for nearly every unit of equipment a brief statement of the purpose of the equipment, the operatives' duties, the size and capacity of machines, the weights and cost of the equipment, the operating and maintenance costs, the power demands, the motor costs, and similar pertinent data.

The low, intermediate, and high figure of costs of operation, repairs, and supplies are meant to cover not the range for mills of any specific size but the general range for all classes, regardless of size or type. So far as possible, the effect of size or type of operation has been mentioned with other factors bearing on such costs, but sufficient data was not available to bring out in each case the exact effect of size of operation on the particular cost item. The machinery and equipment prices are those in effect in 1916. The costs per thousand feet are in terms of the volume of finished product and not log scale or other temporary volumes.

The drawings of machines and equipment are entirely for illustrative purposes and must not be considered in any sense as an endorsement of the style or types shown.

GENERAL CHARACTER OF DOUGLAS FIR MILLS

The first lumbering enterprises in the Douglas fir region, established six or seven decades ago, were small, simple sawmills, producing only rough green lumber. A number of small mills are still in operation. There has been a gradual change in the representative type of mill, however, until now the typical mill is a large, complex plant composed of many units and equipped to turn out lumber products in a variety of conditions and forms.

The early mills were located on the principal harbors of the region, Puget Sound, Grays Harbor, Willapa Harbor, and the Columbia River Harbor, and most of the lumber is still produced at these centers; but the construction of the transcontinental railroads and the inability to obtain stumpage accessible to tide water has led to the establishment of inland mills. These are becoming more numerous each year.

Most of the lumber produced at the plants on Grays Harbor and much of that manufactured on Puget Sound, the Columbia River, and Willapa Harbor is cut by mills which rely solely upon the log market for raw material. Since the development of the inland mills, however, there is less of the tendency, quite prevalent in the past, to establish manufacturing plants independent of logging operations. This is because the inland mills are not as a rule situated where they can obtain logs from a number of loggers. If mills have to rely upon one or two independent loggers for their material, there may not be enough competition to insure reasonable prices, or the mills may be forced to shut down because of inability to obtain sufficient logs.

SIZE OF PLANT.

Over 80 per cent of the lumber produced in the Douglas fir region is manufactured at plants ranging in daily producing capacity from 75,000 to as much as 500,000 board feet. The usual size is probably between 100,000 and 125,000 board feet, although there are many small mills (25,000 to 50,000 daily) successfully meeting the competition of the large operators, particularly in supplying the demand for sawed ties and structural timbers. These usually operate on logs from second-growth timber; and having small investments and limited crews, are able to cut such logs more cheaply than can the extensive and elaborate plants. Simple products can be manufactured from such logs about as rapidly in a small mill as in a large complicated plant and in the former there is a minimum expense for labor, supplies, and repairs.

The tendency now is to build very large plants equipped elaborately for the twofold purpose of securing the profits from the more finished products and of manufacturing into by-products raw material that would otherwise have to be thrown away or burned. Such plants may including planing mills, box factories, etc., and be equipped with machinery for turning slabs and other "waste" into lath.

The enormous amount of capital which has become available for sawmills in the last two decades has played an important part in creating the trend toward larger plants. The early sawmill operators in the fir region, with but few exceptions, had only limited means with which to construct their plants and promote the sale of their product. In recent years the money made in stumpage or obtained thru bonding systems made possible the construction of numerous large plants. The fact that buyers of large quantities of lumber often prefer to deal with only one or two operators instead of a large number, has also been in a way responsible for the construction of large plants. The tremendous output and the diversified character of the product make it necessary to include in the organization of such plants a special force for marketing.

TYPES OF PLANTS

The early mills were principally "cargo mills," so-called because they were built to supply lumber by vessel to domestic and foreign ports. Today not more than 30 per cent of the lumber produced in the region is shipped by water, and most of the mills have been modified to make possible the sale of at least a part of their product in rail markets. The large market for lumber in the Middle West made available by the building of railroads and the growth of the local market through the rapid increase in population of the Northwest are both responsible for this change.

Since ocean freight is based on volume, cargo mills do not need facilities for kiln drying, air drying, dressing, and matching their product, it usually being shipped rough and in the green condition. Due to the facility in loading and unloading which may be gained, many foreign buyers purchase their material in large sizes and resaw it abroad. This practice eliminates large yards, for the lumber is close piled on wharves while awaiting the arrival of the vessels. The rail mills, on the other hand, are equipped with large dry kilns, elaborate planing and matching facilities, and good-sized seasoning yards. Thus there are three distinct types of Douglas fir mills: the strictly cargo mill, the strictly rail mill, and the combination mill, this last being the prevailing type.

The mills of the region may be divided also into two distinct classes as regards their sawing equipment. Originally, the old style circular head saw was universally used for the main sawing operations; but at the present time the band type is used in the majority of cases because of the smaller saw kerf, or "saw waste."

The use of band head saws did not increase so rapidly in the Douglas fir country as in some of the other large lumbering regions because of the cheap logs available in the early days and the scarcity of skilled filers capable of caring for such saws. Furthermore, a large number of plants operated on logs which had been driven to the mills or to tidewater instead of being transported by railroad as is usually done today. Logs transported either by driving or by yarding and railroad contain considerable quantities of grit, gravel, and even large stones, which become imbedded in the surface and cause great damage, especially to the delicate teeth and blade of the modern band saw.

The band head saws at fir mills are usually of the single cutting type, although double cutting saws are used as auxiliary equipment in some of the larger plants.

COST OF PLANT

The investment has increased with the change in the character of the product as well as with the amount of lumber produced daily. A plant of 100,000 feet daily capacity, producing principally rough green lumber, cost in 1916, complete, from $100,000 to $120,000 ($1,000 to $1,200 per thousand feet of daily cut), while a plant of the same size equipped with dry kilns, planing mills, and yard handling facilities cost from $250,000 to $300,000 ($2,500 to $3,000 per thousand feet of daily cut).

CONSTRUCTION AND EQUIPMENT OF PLANT

Owing to the large diameter and great length of the logs in the Douglas fir region, the mills are built of heavier timbers than those in most other lumber producing regions; they are wider and longer for the same producing capacity, and are equipped with larger and heavier machines. The logs at a fir mill average from 28 to 30 inches in diameter and from 32 to 34 feet long,

as against logs from 12 to 15 inches in diameter and from 14 to 16 feet long in the mills of most other regions.

The necessity for giant machines with commensurate power requirements in the fir mill are better appreciated when it is understood that the massive logs, each weighing from three to five tons, are elevated from 30 to 40 feet, reduced to huge cants by being shot back and forth against the main saw at from 300 to 500 feet per minute; that each of these cants, from 4 to 12 inches thick and from 24 to 60 inches wide, is cut to widths at a feed of from 200 to 300 feet; and that the resulting numerous pieces are trimmed to lengths and deposited on a sorting table all in the course of five or six minutes. During the same period from one to three tons of sawdust, slabs, and waste wood and bark are mechanically conveyed to the boiler plant, lath mill, and refuse burner respectively.

MOTIVE POWER

The horizontal steam engine with shaft transmission is the usual type of motive power; but the most recently constructed mills, with but few exceptions, are designed and equipped for electric motor drive, the electric power being generated at the plant.

Electric motors have been in successful use in the planing mills and wood working plants of the region for many years, but it is only in the last decade that the problems retarding their use in the sawmill proper have been overcome. It was an extremely difficult task to apply motor drive to the heavy duty sawing equipment in use at Douglas fir mills. Proper sizes, speeds, and types of motors had to be worked out for each machine; and specially designed motors and appliances which automatically would prevent overloading were necessary for certain machines. Today, individual or semi-group drive with electric motors is a recognized success, and about the only place in the modern Douglas fir sawmill in which steam has not been displaced by electricity is in the motive power for the log carriage and other log handling equipment such as log turners, kickers, etc. Engineers are at work designing a heavy duty electric drive to displace the twin cylinder steam engines now in general use for this work.

CHARACTER AND AMOUNT OF LABOR

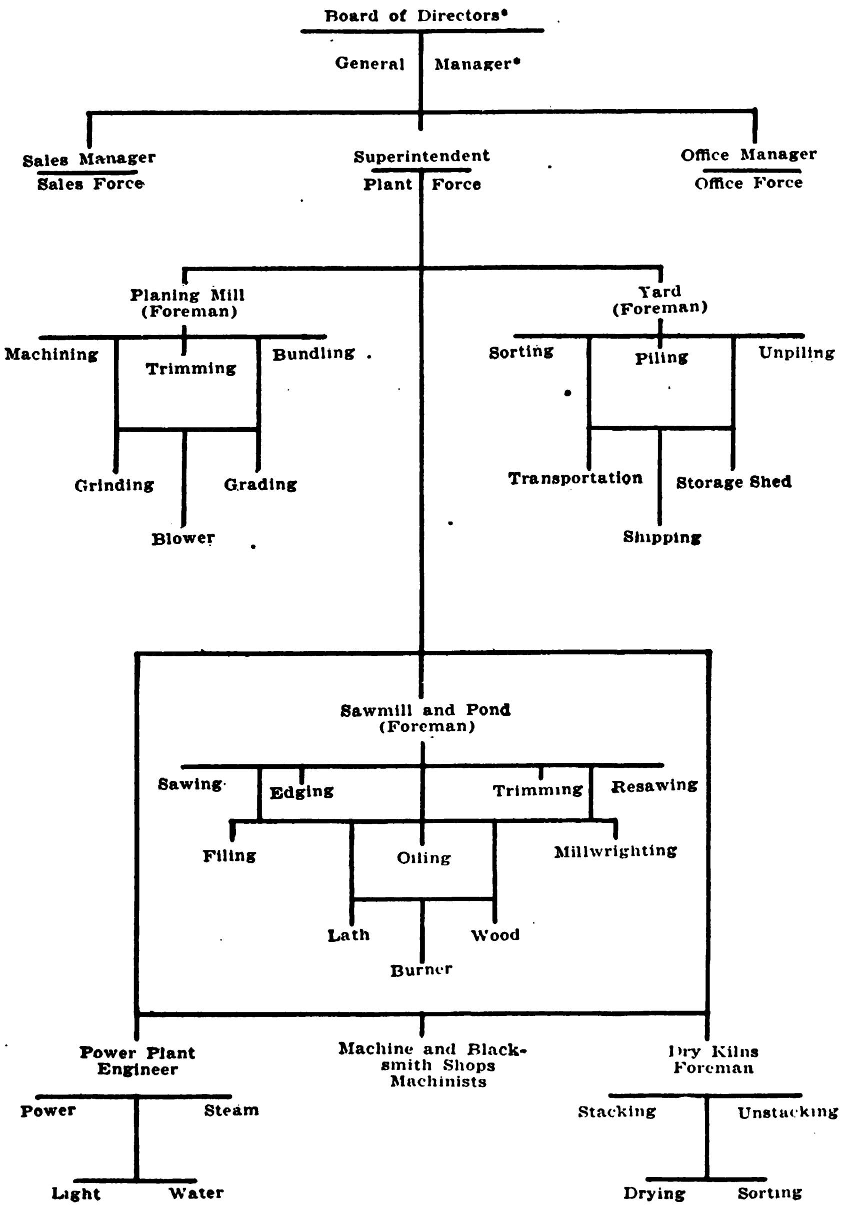
The character of labor required in a sawmill has changed considerably. In the early days the sawyer (who was also the filer and millwright), the engineer, and the bookkeeper were about the only skilled men. Today, particularly at some of the larger and more elaborate plants, the staff of skilled or technical men include experts in saw filing, millwrighting, electrical engineering, production engineering, cost keeping, kiln drying, air drying, lubricating, lumber grading, and a large number of men specializing in work less important, in addition to the numerous superintendents and foremen of the various departments.

Ordinarily, the ratio of the number of men to the amount of lumber is between one and one-and-a-half to each one thousand feet of daily cut, depending principally upon the character of the product. For example, a mill having a capacity of 100,000 board feet per day and producing principally rough, green lumber employs only from 90 to 100 men; while a plant of the same size producing a variety of kiln dried planing mill products and a large amount of dressed or air seasoned lumber often employs from 140 to 150 men.

ORGANIZATION

The division of responsibility is not uniform at Douglas fir plants, but the following organization chart shows the general scheme followed in many of the larger operations. The plan is not intended as a model but merely indicates general practice in the plants of the region. In the smaller plants, the yard and kilns, and sometimes the planing mill also, are under one foreman; while in the largest plants, even the shipping department, the storage shed or sheds, and the transportation system are each under a separate foreman.

ORGANIZATION CHART OF A DOUGLAS FIR LUMBER MANUFACTURING PLANT



* May also direct the logging plant.

SITE SELECTION

In selecting a site for a lumber manufacturing plant, consideration is given to all the factors which affect either the cost of production or the efficiency of the operation. These factors are not always of the same relative importance but vary with the conditions in each case. The order in which they are placed here is, therefore, without significance.

SIZE AND COST OF SITES

The size of sawmill sites required for mills of various capacities depends upon the provisions for log storage and lumber storage. To some extent it depends also upon the character of product manufactured.

The size of log pond or water area for log storage is obviously dependent upon the minimum and maximum quantity of logs to be held in reserve. Mills located in the large log markets of the region, such as Willapa Harbor, Grays Harbor, Puget Sound, the Columbia River, and Coos Bay, require small storage areas because they can always draw on the market should the supply from their own camps be temporarily shut off. Mills entirely dependent on their own or any single source of supply must provide for sufficient log storage to keep the plant in operation during interruptions in log delivery, which are quite frequent even under the best conditions. Representative log storage areas for rail and cargo mills are shown below. Many mills are operating with less storage facilities than the minimum shown, but usually only when other conditions make it impossible to obtain larger areas at reasonable cost.

SIZES OF SITES FOR MILLS OF VARIOUS CAPACITIES

Class of mill	Annual cut of mill million board feet	Log storage (pond) acres[1]	Plant. acres	Yard acres	Total, acres
Rail	8-10	2- 5	3- 5	2- 3	7-13
Rail	15-20	3-12	5-10	4- 6	12-28
Rail	30-40	5-20	10-15	8-12	23-47
Rail	60-70	10-30	15-20	12-16	37-66
Cargo	30-40	3-10	12-18	3- 6	18-34
Cargo	60-70	5-20	18-22	6- 8	29-50

[1] At rail mills this depends upon log supply desired.

Mills planned to supply the rail trade must provide for large seasoning yards to remove the surplus moisture from their stock before shipment. For this reason the rail mills require larger yard area than cargo mills, at which, pending the arrival of vessels, the lumber can be piled on the docks or on scows because water lumber rates are not based upon weight, but upon space occupied. The areas given for lumber storage are typical and do not represent extremes. Some cargo mills handle considerable rail business and often have yards as large as those of strictly rail mills.

The total area shown for rail and cargo mills includes areas occupied by buildings, roadways, docks and platforms, and those made necessary by insurance regulations. Because the dock sites are included in these figures, the total areas for cargo mills are greater than those for rail mills. Frequently they are the same for rail as for cargo mills because the spaces used by the planing mills and kilns at rail mills are eliminated at cargo mills.

The cost of mill sites varies from a few dollars an acre in unsettled regions to several thousand dollars an acre in or near large cities. Cargo mills very frequently have costly sites because of the frontage on navigable water. Such frontage inside of city limits often costs as much as a thousand dollars per linear foot. Many mills are now located on such sites, but they

can not be considered an economic success unless the community is developing so rapidly that appreciation offsets the high carrying charges on the property.

From the standpoint of cost of site, the ideal location is one which combines shipping facilities with a minimum outlay of money, since the value or volume of business conducted per square foot of area occupied is exceedingly small. Generally speaking, it is inadvisable to locate a sawmill on land worth more than $1,000 per acre, unless there is sufficient timber to furnish a supply lasting several decades or unless it is increasing in value, since the high overhead cost is seldom offset by factors making such a location desirable.

Sawmill sites, like those of other industries, vary so greatly with conditions that it is very difficult to give representative figures for site costs. The following may serve as a guide.

COST OF SITES PER ACRE

	Urban	Suburban	Country
Inland sites	$1,000- $3,000	$300-$1,000	$10- $300
Tidewater sites	$3,000-$10,000	$1,000-$3,000	$500-$1,000

These costs depend largely upon the shape of the property, especially for tidewater sites. since the amount of water front is an important factor.

FUTURE VALUE OF SITE

Possible increase in site value is naturally most to be expected in urban or close-in suburban localities. Most of the mills now located in or near the center of fairly large cities were built when such places were small. Sites which were bought at from $100 $200 an acre are now worth from $10,000 to $20,000 an acre, and are held and used as sawmill property only because continued increase in value offsets the high carrying charges.

In rural districts the coming of a large mill usually increases the value of all land in the vicinity, the increase being in direct proportion to the extent of permanent development in the immediate territory. Where clearings are made for the construction of small mills, the value of the site at the expiration of the cutting operation is often not greater than that of the cleared land. If the site and surrounding land is not suitable for agriculture or mineral development and similar uses, the land may reach its highest value when used as a mill site, and when the mill is removed the entire area is a barren waste, which causes an actual depreciation in all land values in the territory. Should the land become reforested, naturally or artificially, the site might resume its normal value or even acquire a higher one.

TAXES

Those mills located within the corporate limits of cities and towns are subject to high city taxes and do not enjoy any special advantages over those located just outside the corporate limits, except where appreciation in property values and sales of slabwood are sufficient to offset increased taxes.

FIRE INSURANCE

Mills inside the city limits may enjoy reduced insurance rates owing to the proximity of city fire fighting equipment, but there is frequently adjoining property which increases the risk of fire and offsets the advantage. Mill fires are usually of internal origin, so that city mills and suburban mills are forced to equip their plants with the same character of fire fighting apparatus and to arrange them so as to prevent the spread of fire. City plants

are also necessarily congested because of the high cost of the site. This adjacency of the several buildings and yard brings about a higher insurance rate. The character of industries on adjoining property is to be carefully considered; for unless fire walls or lanes are used there is great danger from fire from exterior sources.

LABOR SUPPLY

Mills in isolated regions are very frequently forced to employ an unstable class of labor, since married men with families do not care to go into regions where the children are unable to go to school. The unmarried men, who can more easily be induced to work in remote regions, are inclined to stay only a short time, and, for this reason, often do not work as hard as men desiring to make a permanent place.

Large operators employing a considerable number of men can afford to provide the schools and entertainment demanded by men with families. They are therefore able to keep a better class of men at their plants at all times, even in remote regions.

Whether labor may be readily secured must also be considered. It is therefore best, wherever possible, to locate the plant close to a fair-sized town or city. In remote regions it is difficult to obtain men on short notice. Frequently railroad transportation must be furnished, for men out of work seldom have sufficient ready money for even short trips. At plants located near fair-sized towns or cities there is usually an abundance of men to be had, even on short notice, and the work at the mill is not seriously handicapped when a man or several men quit. The knowledge that there are plenty of men to take their places also tends to increase efficiency among the employees.

WATER SUPPLY

Clear, soft water for boilers, fire protection, and drinking purposes is a great asset to a sawmill. Little difficulty has been experienced in finding this in the Douglas fir region, although one or two mills have been forced to install rather expensive water works. Some mills are fortunate in being able to use city water at a nominal cost.

The water item is ordinarily of importance from a standpoint of cost only where water development is expensive or charges for city water are high. It is a very important item, however, where artificial log ponds are necessary and the supply of water limited.

Mills which do not have log ponds are forced to pay $1.00 a hundred more for their fire insurance than those where so-called "wet logs" are cut.

POWER SUPPLY

In the case of steam mills, there are no unusual features which connect power development with plant location. In the case of electric mills, the possibility of obtaining cheap hydro-electric power, through development or purchase, should be kept in mind as it may be possible to obtain such at a cost less than that of the steam power if the plants are located advantageously. Assuming that the fuel of a sawmill costs nothing the only costs of power generation are the interest on the power plant investment, and the wages for attendance on the boilers and engines, so that, for continuous operation the steam plant will probably be the more economical. The economy of purchased power is particularly apparent at mills which can dispose of their waste at a profit. The income from waste sale will then write-off a part of the power bill and in this especial case that which

would be fuel at no cost, as assumed above, is here a saleable product and therefore chargeable against the plant if used for boiler firing at the mill. The size of the mill has much to do with the quantity of scrap or waste made. Bearing in mind then the last argument, it is often advisable and economical for a plant to buy a portion of its power (electrical) and make the balance, the proportion of power made at the sawmill to that bought being determined by the quantity of waste (depending upon the size and nature of the mill) and its relative value in dollars for boiler fire on the one hand or as a saleable product or by-product on the other. In the case of long or frequent shut-downs the electric system will eliminate all of the costs mentioned during such idle periods, but it must be remembered that in any case steam is necessary for the operation of log turners, kickers, carriage feeds and other control equipment. Again, sawmill plants fortunately located can frequently sell sufficient surplus power to reduce materially the cost of that which they utilize.

COST OF MILL CONSTRUCTION

The cost of building a sawmill is in direct proportion to the accessibility of labor, brick, cement, equipment, timber, and other elements entering into its construction. Sites remote from main line railroads or at points not accessible by rail cost from 10 to 25 per cent more to build on than those near main lines. This is due to the high cost of delivering the materials and to the extra charges made by carpenters, masons, mechanics, and other laborers needed on the work.

Plants located on tide lands and on sites where foundations are difficult cost a great deal more than those for which special construction is unnecessary. The construction of docks for cargo shipments, dredging, excavating for log ponds, draining, grading for yard, setting of special footings, and other factors abnormally increase the cost of constructing many mills.

FACILITIES FOR REPAIRS

Mills located close to manufacturing centers do not require elaborate machine shops for repairing broken parts and making new equipment needed on short notice. They frequently do have such shops, but this is customary only in the very large plants having enough work to enable them to operate such a shop on a paying basis.

In isolated regions it is usually necessary for even the smaller mills to have complete machine shops, for any delay in replacing broken parts greatly reduces the productivity of the plant. The overhead expense in operating a sawmill is usually so great that the most important feature of mill management is to keep the plant running constantly. This overhead expense amounts to from $100 to $200 a day in plants of the usual size; so that the additional expense of maintaining a machine shop, even though it is operated at a slight loss, is entirely justified by the important part the shop plays in the continuous operation of the plant.

The main point to be borne in mind in considering the necessity for operating a machine shop is the ability to obtain parts without delay. Where the delays are short, it is better to lose a small amount of time than to in crease the investment as much as is necessary to properly equip a machine shop, although some operators believe that the saving incident to being able to purchase rough castings makes a shop always more or less desirable.

Mills located in inaccessible regions frequently avoid shut-downs by keeping on hand duplicate parts of all the vital breakable equipment. Where many parts must be kept on hand, this practice greatly increases the in-

vestment, but the saving on one breakdown will frequently pay a year's interest on the entire stock of duplicates. The amount of money which should be spent in this way and the kind of parts which should be kept on hand are determined by estimating the possibility of breaking each part and the loss in overhead expense for the period required to obtain the parts from supply houses or to manufacture them in company shops.

STORAGE FACILITIES

Nearly any site can be equipped for log storage, provided a sufficient water supply is available. The ideal storage is in lakes or sloughs where the water is not affected by tides and currents. A few piles for anchoring the boom sticks to form a booming ground or for attaching the rafts is all that is required. Where these lakes or sloughs freeze they are somewhat less desirable because provision must be made for heating the log pond. This is usually done by the use of exhaust steam from the engines.

Salt water log ponds are very satisfactory in protected situations, although it is necessary to make special provision for the rise and fall of the tides. The tides also increase the difficulty of feeding the logs into the log slip, because of the current. Salt water ponds in partially exposed sites require large boom sticks and special devices to prevent the logs from being carried away by the waves and undertow. Logs stored for a long time in salt water inhabited by teredos and other borers are likely to be attacked and partially destroyed.

Rivers and streams sometimes must be dredged. And they have other objectionable features. The current causes difficulty in sorting and handling logs, often necessitating the services of an extra boom man. During the high water period when the streams are swift, rafts of logs frequently break loose and are carried away. These rafts either are recovered at considerable expense or are a complete loss.

The swift river currents frequently carry debris, which is deposited on the foot-sheave of the log slip and is likely to put the slip out of commission during the high water period. Many mills have been troubled in this way. In addition to shutting the mill down it sometimes makes necessary the hiring of divers to remove the deposit before the slip can be properly operated. A hinged slip (Fig. 1) eliminates this trouble in getting at the foot sheave.

The cost of constructing a yard suitable for storing and seasoning lumber is an important item. If the land is at all wet, drainage must be provided, for certain species of wood cannot be seasoned on swampy sites without staining or mildew. Ample room must be provided for storing several months' cut, since the fluctuating demand for lumber makes a uniform disposition of the manufactured product impossible. The topography and geography of the lumber storage area are important economic features. Artificial yards are frequently built by filling in low land with refuse from the mill. This method has been successfully used, but is objectionable because it increases the fire hazard.

It has not been the practice in the past to air season much of the Douglas fir lumber and the lumber storage area has, therefore, not been so important an item in selecting a site. Of recent years there has been a greater tendency to dry the stock before shipment, so that the storage area is now considered one of the principal factors in mill site selection.

High valued property necessitates reducing the yard space to a minimum. This frequently leads to inadequate space and necessitates group piling of several kinds or grades of lumber, requiring unnecessary labor in preparing lumber for shipment when given sizes and grades are ordered. The area

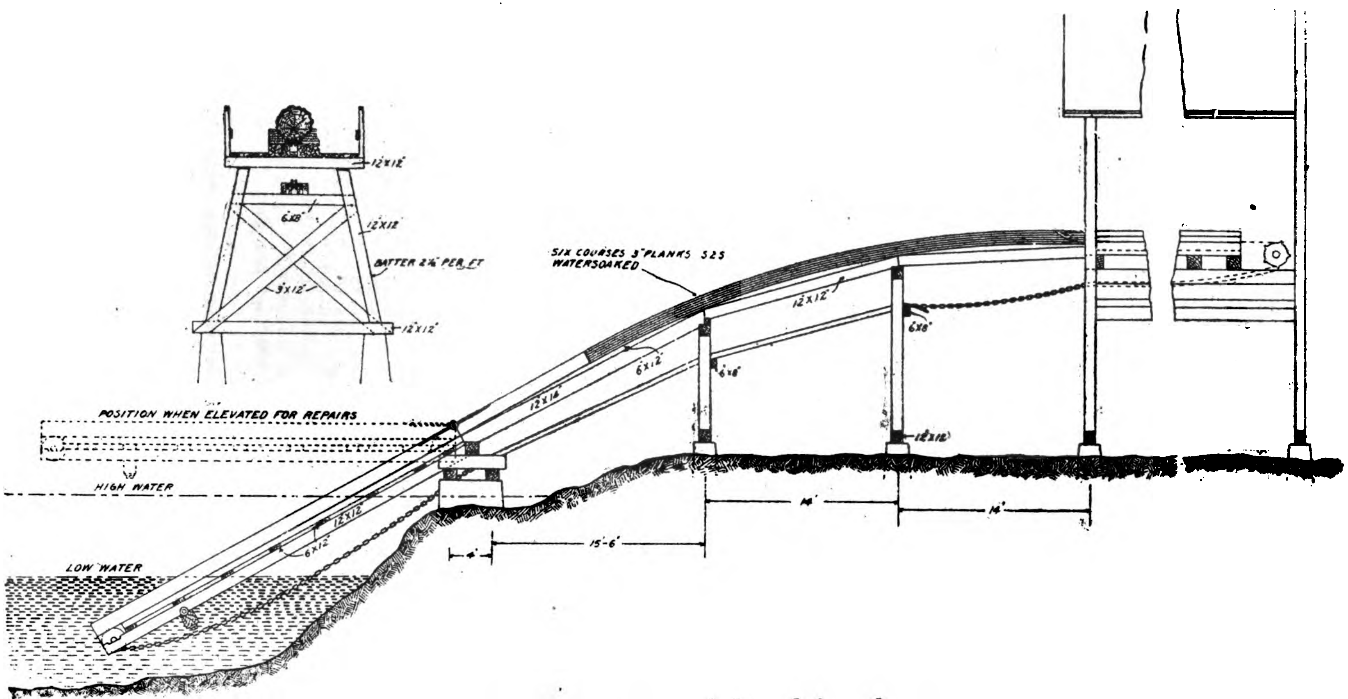


Fig. 1. Slip type of hoist with hinged foot sheave.

should be sufficiently large to avoid undue rehandling in selecting lumber for shipment, even though the investment is materially increased, since it costs a minimum of 25 cents a thousand every time lumber is handled.

DISPOSAL OF WASTE.

Sawmills located in or near fair-sized cities have an opportunity to dispose of the slabs and edgings for household fuel and in the "hogged" form, for boiler plant fuel. This is a decided advantage; for it reduces the size of or eliminates the costly refuse burners, and produces a revenue of from $1.00 to $1.50 per cord, which amounts to from 40 to 65 cents per thousand feet. Rural mills usually have no use for this material except in the manufacture of lath, and are frequently forced to dispose of all their waste by destroying it in refuse burners or using it to fill in low ground around the plant.

DELIVERY OF RAW MATERIAL

The accessibility of the timber is an important feature of mill location, since cheap transportation of the raw material is necessary. Water transportation is the cheapest and is used wherever logs can be towed or driven without too great loss. The following tabulation of water rates from Puget Sound should serve as a guide to the relative merits of rail and water transportation when the selection of a site is under consideration.

Distances	Cost per 1,000 board feet log scale (1916)	Distances	Cost per 1,000 board feet, log scale (1916)
0-15 miles	$0.15	60-70 miles	$0.50
15-20 "	.20	70-80 "	.55
20-30 "	.25	80-90 "	.60
30-40 "	.30	90-100 "	.65
40-50 "	.35	100-110 "	.70
50-60 "	.40	110-120 "	.75

The above applies to rafts of 300,000 feet or more, this being the minimum any raft is considered to contain in figuring a towing charge. Towing is done at the owner's risk.

Following are rail transportation costs:

Distances	Cost per 1,000 board feet log scale (1916)	Distances	Cost per 1,000 board feet, log scale (1916)
0-10 miles	$1.00	55-60 miles	$1.75
10-15 "	1.25	60-65 "	1.80
15-20 "	1.35	65-70 "	1.85
20-25 "	1.40	70-75 "	1.90
25-30 "	1.45	75-80 "	1.95
30-35 "	1.50	80-85 "	2.00
35-40 "	1.55	85-90 "	2.05
40-45 "	1.60	90-100 "	2.10
45-50 "	1.65	100-110 "	2.15
50-55 "	1.70		

Minimum load 7,000 feet per car.

Good sites must be accessible for delivery of logs regardless of tides and stream fluctuations. The character of the log pond which will be available at the mill must be duly considered; floods and swift currents are difficulties in fresh water, while tides and breakers cause trouble in salt water.

SHIPPING FACILITIES

A good mill location should permit of either rail or cargo shipments direct from the plant. Interior mills will be handicapped in water shipments and water-locked mills in rail shipments. These difficulties may be

largely overcome by equipping water-locked mills with railroad car barges and by using barges in lightering where mills are not accessible to ocean going vessels. In the Puget Sound region railroads furnish free car barge service to mills located within the limits of their terminal rates, but this free service applies only from competitive points, otherwise a slight charge is made.

Approximately 75 per cent of all Douglas fir lumber is marketed by rail or wagon. Accessibility to rail shipping is at the present time of greater importance than accessibility to cargo shipping, and there are very few mills now in operation which do not have rail connections either direct or through the use of barges.

The cost of constructing spurs from the main or tap line is important. The policy of roads is to have the user bear all of the expense of installing a great number of spur tracks, except that the railroad furnishes the track metal with certain rental charges. This applies only to ordinary short commercial spurs.

Although mills may have good rail shipping facilities from the standpoint of topography, they are frequently handicapped by geographic and other conditions which necessitate extra freight costs in marketing the product. These extra costs may apply to all shipments or to shipments to certain points or for delivery on certain railroads. They are called differentials, and are a very important item in site selection. They usually occur where the mill is located on a small independent road connecting with a transcontinental carrier. They may, however, occur on "tap lines" of large transcontinental roads, or even on main lines of transcontinental roads, should the destination necessitate routing the shipment for delivery on a competing line.

The possibility of securing cars in quantity and variety on short notice is important. In certain localities and at isolated points where no stations exist it is often very difficult to obtain cars, at least the size and style of car required to transport a given class of material. Box and cattle cars can be used for kiln-dried lumber but gondolas and flats are entirely unsuited to this material. Timbers can not be easily loaded into closed cars. Silo stock and other long material necessitate large cars with open ends to facilitate loading. During the car shortages of 1907 and 1916, those firms nearest to the railroad centers were best able to get cars, although all mills were more or less handicapped.

Railroads frequently do not furnish freight service to isolated shippers more than once or twice a week, making it necessary to anticipate car needs and greatly delaying the dispatch of rush orders. The infrequent service often necessitates larger spur tracks and platforms, and may greatly increase demurrage charges where cars are not ready for shipment at specified times.

The ability to make direct cargo shipments is a great site asset, and is especially so now that lumber carrying steamers are plying through the Panama Canal to eastern and European markets. Deep water is preferred, since lumber can then be picked up from the mill docks and loaded direct. Where this is not possible, it is good practice to have a fleet of scows upon which the lumber can be stored during the cutting period, awaiting the arrival of the steamers. The scows can be towed to the vessel and the loading done at no greater expense than from the docks. Lumber handled in this way is carried to the boat at the owner's risk. Should the scows capsize or material be lost overboard, the steamer owner is not responsible. This and the expense of maintaining the scows are disadvantages avoided by selecting deep water sites. But a site where scows can be used is more valuable than one inaccessible to any kind of water transportation, since water shipments from inland plants necessitate rehandling the lumber at the railroad terminal, as well as the payment of short haul freight costs.

CONTACT WITH MARKET

Contact with the lumber market in the large centers, such as Portland, Seattle, Tacoma, and similar points, is an important factor in the location of mills. Mills in remote places are frequently forced to maintain offices in these market centers at a cost of from $250 to $500 a month in order to be in contact with the trade. These offices are usually, but not always, the sales offices of the company, so that the sales office is separated from the mill, which is generally undesirable. No matter how complete or frequent reports of "stock on hand" the mill makes to the sales office, the sales office without a knowledge of the class of logs available is at a disadvantage. Letters and telephone conversations with the mill and woods superintendents are never as satisfactory as interviews "on the ground." If the sales offices were at the mill, the sales manager, through contact with the mill, the stock and the superintendents and others, would be able to tell at once whether or not an order could be accepted for immediate delivery or if not whether conditions would warrant accepting the order for special manufacture or future filling in ordinary course. Orders for ordinary material can be handled through separate sales offices without fear of complication, but special sizes, grades, and products must be taken up with the mill superintendent and the foreman. Furthermore, contact means better cooperation between sales and maunfacturing departments, for they can then look at an order from the same angle.

RETAIL TRADE

Urban and suburban mills almost invariably operate a retail department, and in this way often receive a very fair price for a considerable portion of their output. The retail market is one of the most attractive features of city sites, and where there is a reasonable demand for lumber this part of the business frequently produces sufficient revenue to offset a large part of the extra cost of city property.

Municipal development and competition are the important factors influencing the amount of revenue to be expected from the retail department. Where competition is keen many manufacturers prefer not to enter the retail trade owing to the additional expense of teams, trucks, supervision, bad accounts, and other factors involved in this class of sales.

CLIMATE

Plants located where the climate permits continuous operation throughout the year have an enormous advantage over those which are able to operate only eight or nine months. The effect of seasonal operations on various factors such as overhead expense, character and efficiency of labor, depreciation, maintenance, and investment, is obvious. In the Douglas fir region most mills can operate throughout the year.

SAWMILL PLANT

A typical lumber manufacturing plant in the Douglas fir region is composed of such units as (a) a log storage pond, or boom, if on a large body of water, (b) the sawmill proper, (c) sorting and grading tables and sheds, (d) transportation equipment for moving the product about the plant, (e) dry kilns and auxiliary equipment, (f) a storage and seasoning yard, (g) a rough lumber storage shed, (h) a planing mill for surfacing and matching the various forms, (i) a dressed lumber storage shed, (j) a shipping spur or spurs, (k) a power plant, (l) a refuse burner, and other less important units.

The general arrangement of these respective units at a plant of 200,000 board feet daily capacity is shown in Fig. 2. The relative position of each unit depends on such a variety of conditions—size of plant, topography, size of site, character of product, shipping facilities, and similar factors—that the arrangement cannot possibly be uniform. The aim in each case is efficient routing of the material from the sawmill to and through the various departments and thence aboard the cars or to the docks. Arrangement is one of the most essential features and one of the most difficult problems of mill construction, especially where peculiar topography or limited space is encountered.

POND

The log pond serves three very important functions. It is primarily a storage place for logs awaiting the saw. Its greatest advantage over dry storage in piles is that the logs are easily handled and sorted to meet sawing demands. One man can readiy handle large numbers of logs in a pond, while dry storage in large quantities usually requires more men and some machinery. The second function is to clean the logs of grit, gravel, and other foreign material which would dull the saws. The third is to reduce the insurance rate, which is lower in mills cutting wet logs (Page 146).

Natural log ponds are protected places on lakes, rivers, or oceans; artificial ponds are reservoirs made by damming or dredging small streams. Natural ponds on lakes are the most desirable in the fir region, for they seldom freeze and they have none of the objections of river and ocean ponds mentioned above. Furthermore, such ponds are very inexpensive, since the only cost, exclusive of site cost, is for piling and boom sticks. Artificial ponds are the most costly because of the expense connected with damming or dredging. In addition, there must be available sufficient water to keep such ponds properly filled during the dry season, when summer streamflow and maximum evaporation reduce the volume of water. A high average value of evaporation in the fir region is about 12 inches per month; and where the volume of water is at all questionable, the services of a hydro engineer are necessary to make tests on streamflow, vaporation, and seepage, and to insure proper dam construction to conserve as much as possible of the available water.

The cost of the log pond varies so much that it is difficult to give cost figures which will do more than serve as a rough estimate.

Dams built to form ponds for Douglas fir mills have cost from $2,000 to $10,000, depending upon the size of the pond required and the height and character of the dam. Timber dams of either hewn or sawn pieces are most common. The piling and boom sticks used in fastening and corraling logs in both natural and artificial ponds cost from $500 to $1,500, depending upon the size of the pond and the amount of sorting necessary. When logs are delivered by rail, a log dump long enough to provide for several cars is usually necessary. These dumps cost from $1.00 to $12.00 per linear foot, and they are often several hundred feet long.

From one to three men are required on the log pond. This work consists of unloading cars when logs are delivered by rail, scaling or counting logs which come in rafts, bucking, pushing the logs through the water to within pike pole reach of the log haul or hoist, and feeding the logs to the hoist. Sometimes at small mills the pond man operates the hoist and looks after the deck, but at large plants the pond men to not leave the pond.

The cost of operating the log pond varies with the size of the mill, the method of delivering logs, and similar factors. It runs from 2 to 9 cents, the average cost being about 5 cents, per thousand board feet. Where no bucking is done, the average is close to 3 cents per 1,000. The pond supply and repair items are usually included in the general mill figures and are ordinarily too small to need special discussion.

Many Douglas fir log ponds are equipped with drag saws (Fig. 3) to cut long logs to desired lengths for filling specific orders. This practice assists in getting out rush orders for desired lengths with the minimum waste and makes it possible to have the bucking done by skilled men who know the quality of logs and are able to dissect the tree in such a way as to put the clear and common portions into respective logs.

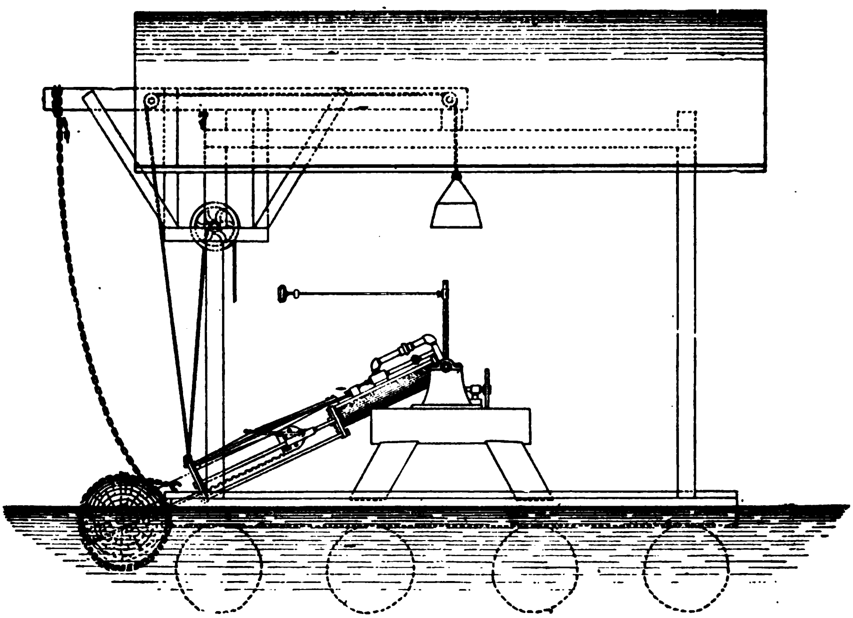


Fig. 3. Steam drag saw for cutting logs to length on pond.

Drag saws are designed and built for either steam (Fig. 3) or motor drive. They cost about $350 to $450 (1916) and weigh about 2,200 to 3,500 pounds, exclusive of steam connections or motor. A 15 H. P. motor costing about $325[1] and weighing approximately 800 pounds is ample. One man can handle a machine unassisted. It works very rapidly, cutting a log from 2½ to 3 feet in diameter in two or three minutes.

[1] 15 h. p.-900 r. p. m. motor with base, pulley and starting compensator (1916).

BUILDINGS

TYPES

Every sawmill in this large producing area is of wooden construction. The advantages claimed for steel, such as fire resistance, durability, portability, and easy retention of alignment of shafting apparently have not offset such desirable features of wooden mill buildings as low first cost, easy alteration, and resilience—the last an important factor in the wear and tear on machines. Furthermore, the temperature in steel mills is said to be disagreeably high in summer. Designs for wood frame construction are shown in Figs. 4, 5[1] and 6[1].

FOUNDATION PILING

Most of the mills are built upon piling because they are located on tideland or river front property. Furthermore, piles are cheap, and little trouble has been experienced from either decay or insect attacks.

The length of the piles varies considerably with the depth of both the water and soft earth, but the average length is indicated by the fact that more 50 and 60 piles are sold in the region than those of any other length. The butt diameters vary with the length of the piles from 14 to 18 inches, while the tops vary from 9 to 10 inches.

The costs of foundations are so extremely variable that it is rather difficult to give accurate figures unless at least two of several variables are known. The following are the costs of foundation piles installed (exclusive of caps) for various lengths and costs of piles, the driving costs being estimated at $1.50 each for 20 foot; $1.75 for 30 foot; $2.00 for 40 foot; $2.25 for 50 foot; and $2.50 for 60 foot piles.

COSTS OF FOUNDATION PILES INSTALLED

Length of piles, feet	Cost of each pile per linear foot					
	5c	6c	7c	8c	9c	10c
	Cost of each pile installed					
20	$2.50	$2.70	$2.90	$3.10	$3.30	$3.50
30	3.25	3.50	3.85	4.15	4.45	4.75
40	4.00	4.40	4.80	5.20	5.60	6.00
50	4.75	5.25	5.75	6.25	6.75	7.25
60	5.50	6.10	6.70	7.30	7.30	8.50

Piling costs vary with the accessibility of the location, so that only general averages can be given. Representative selling prices of Douglas fir piles in 1916 were: 20 foot—6c, 30 foot—8c, 40 foot—9c, 50 foot—9c, and 60 foot—10c. If piles are taken from the woods in connection with a mill's logging operations, they can often be obtained for less than open market prices.

CONCRETE PIERS

Concrete foundations are not extensively used because as a rule they are more expensive than piles and their additional durability is seldom demanded, the life of the wooden piles being as long as the life of the average mill. Where exceptional permanency is desired or where the character of the soil makes pile driving difficult, concrete piers are used. These contain from ½ to 2½ cubic yards of concrete each, depending upon the weight of the machines to be installed and the character of the ground.. One cubic yard is ample for ground having reasonable holding power. The cost per square yard varies not only with the size of pier, but also with the availability of sand, gravel, and cement, the amount of excavating necessary, and to some extent with the form used. The following are approximate figures of cost for individual piers of typical sizes.

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[1] On page 44-45.

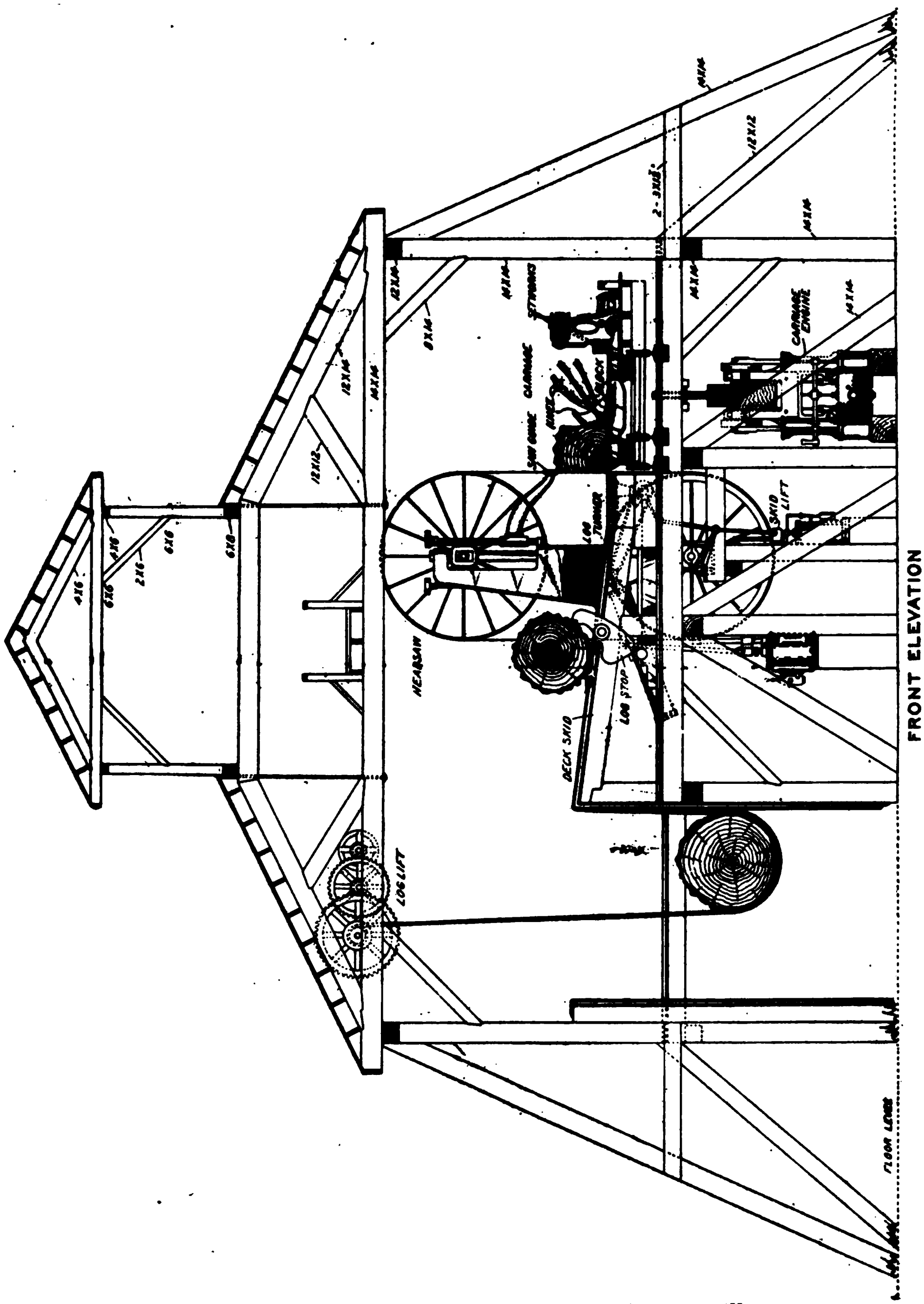


Fig. 4. Elevation of a single band Douglas Fir sawmill.
(Designed by Howard B. Oakleaf.)

COSTS OF CONCRETE PIERS (1916)

Size of pier, cubic yards	$ 6.00	$ 7.00	$ 8.00	$ 9.00	$10.00	$11.00	$12.00
	Cost of each pier installed						
0.50	3.00	3.50	4.00	4.50	5.00	5.50	6.00
.75	4.50	5.25	6.00	6.75	7.50	8.25	9.00
1.00	6.00	7.00	8.00	9.00	10.00	11.00	12.00
1.25	7.50	8.75	10.00	11.25	12.50	13.75	15.00
1.50	9.00	10.50	12.00	13.50	15.00	16.50	18.00
1.75	10.50	12.25	14.00	15.75	17.50	19.25	21.00
2.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
2.25	13.50	15.75	18.00	20.25	22.50	24.75	27.00
2.50	15.00	17.50	20.00	22.50	25.00	27.50	30.00
2.75	16.50	19.25	22.00	24.75	27.50	30.25	33.00

(Column heads: Costs per cubic yard)

FRAME

A typical frame is shown in Figs. 4, 5 and 6. The log deck of the mill is of much heavier construction than the remainder of the flooring because of the severe stress developed in handling the heavy logs at this point. The braces shown in the drawings are notched into the sides of the posts to increase their efficiency, although this practice is not always followed. Sometimes both ends are merely beveled and spiked; or the braces are nailed on the sides of the posts and stringers.

The lumber used in the frames ordinarily costs from $10 to $12 per thousand, and the labor of putting it up from $6 to $8 per thousand. There are from 60 to 80 pounds of hardware, which costs about three cents per pound, used to each thousand board feet of lumber. (Costs of 1915-1916.)

WALLS AND ROOF

The walls are usually of 1 x 12 boards, surfaced two sides. They are run up and down, and the cracks are covered with flat or OG battens. Recently, low grade channel rustic has been substituted for boards. The effect is more pleasing and there is little difference in cost.

The roofs are covered with high grade roofing materials of various kinds. Heavy tarred papers are most common, although in some of the better class structures the more expensive prepared roofings are used. These materials vary in cost from 3 to 5 cents per square foot, depending upon the quality.

WINDOWS

The size and number of windows are not uniform, and on the whole there is a tendency to reduce too much the areas for light. Factory windows of the type required for sawmills cost only 15 or 20 cents per square foot, and plenty of light can be provided without materially increasing the cost of the structure.

COST

The following figures give a general idea of the cost of constructing mill buildings. They are representative of good construction, but they should not be used unless time and data are not available for a more accurate estimate.

COST PER SQUARE FOOT OF AREA COVERED BY BUILDING[1]

Item	Heavy (High)	Medium	Light (Low)
Lumber (at $10.00 per 1,000)	$0.40	$0.35	$0.25
Labor	.30	.25	.20
Hardware	.11	.09	.07
Roofing	.06	.04	.03
Glazing	.06	.05	.04
Foundations	.04	.03	.02
Miscellaneous—Painting, etc.	.03	.02	.01
Total	$1.00	$0.83	$0.62

These costs are for the building proper. They do not include any labor or material used in installing machines. They are for the usual mill with two stories for the machinery and a file room on the third floor. They do not include leantos or other additions to the main mill.

[1] Outside measure.

SAWMILL MACHINERY

LOG HOISTS

The portion of the equipment used to elevate the logs from the pond to the mill deck is referred to by a variety of names such as log jack, log haul up, log hoist, log lift, and the like.

The most common type of hoist at the older mills is the endless chain type operating in an inclined and arched trough or chute. (Fig. 1). The chains are equipped with dogs which grip the log at one or several points and convey it up the chute to the deck. Sometimes when this class of hoist is used the logs are passed through a powerful water spray which cleans them thoroughly for the saw. The lower portion of the hoist shown in the illustration is hinged so that the foot-sheave can be repaired.

The latest kind of hoist is the sling type (Fig. 4), which costs less to put in than the old style, and is claimed to be more efficient. Two three, or four cables are used to form the sling, depending upon the length of the logs. One end of each cable is fastened to the deck at points along or near the upper edge, and the other end of each is fastened to a series of drums on a shaft mounted upon the roof trusses. By rotating this shaft the cables are shortened or lengthened and the sling raised or lowered. Large logs can be raised singly and small ones in twos or threes.

COST

The old style hoists cost complete (with unloading device) from $4,000 to $10,000 (1916), depending upon their length and design. The cost of the sling type is shown in detail below.

COSTS OF SLING TYPE HOISTS (1916)

Item	Heavy	Medium	Light
Shafting (and coupling) per foot	$ 4.00	$ 3.00	$ 2.00
Cable per foot	0.22	$.20	0.18
Drums, each	18.00	15.00	12.00
Boxes, each	7.00	6.00	5.00
Gears and shafting for drive	150.00	125.00	100.00

POWER

The size and cost of the motor required for the log hoist depends upon the rate at which the log is elevated and the size of the log and equipment. The following power data are illustrative:

Slip hoist:

Total horizontal length of haul	feet	200
Length of horizontal section (at top)	feet	70
Grade of inclined part (usually 25 to 30 per cent)	per cent	27
Approximate elevation above water	feet	35
Speed of chain (usually 75 to 100 f. p. m.)	feet per minute	45
Average input—light	Kw.	11.7
Maximum observed input	Kw.	70
Maximum sustained input (duration 50 sec.)	Kw.	37
Estimated average power used, including time idle	Kw.	11.2

Sling hoist:

Hoisting with 4 1-inch cables	feet per minute	15
Speed of hoisting	feet per minute	15
Input lowering cables	Kw.	2.42
Average input elevating log	Kw.	11
Kicking log up onto deck (instantaneous)	Kw.	40-50

The size and cost of log hoist motors are given below. All are alternating current motors. Costs include primary oil switches with overload and low voltage protection, necessary drum type controllers and starting resistance. No gears included.

COSTS OF LOG HOIST MOTORS (1916)

Size of motor	Weight, pounds	Cost delivered
15 h. p., 900 r. p. m.	1,450	$471.00
25 h. p., 900 r. p. m.	2,050	600.00
35 h. p., 900 r. p. m.	2,350	671.00
50 h. p., 900 r. p. m.	2,950	823.00

LOG DECK

The log deck (Fig. 4) is that portion of the mill where the logs are stored and handled prior to and during the sawing operation. The decks are ordinarily made single as shown, but may be double, triple, or even quadruple in the very large mills, the general arrangement and equipment being about the same regardless of the number of decks under one roof. Single deck mills are divided into right and left hand—the one shown is right hand. The decks should be made steep enough to prevent flat or crooked logs from lodging part way down the skids.

The length of the deck varies with the length of the logs to be handled, and the width with the number of logs to be stored. Ten to twelve feet of storage is ample at fir mills of ordinary size, since there are seldom more than two or three logs on the deck at once.

The deck skids are usually spaced from 8 to 12 feet apart; the number of skids varies, of course, with the length of logs. The skids are usually made of 14 x 18 or 14 x 20 timbers, shod with steel plates or railroad rails. The metal costs from $20.00 to $25.00 for each skid.

The deck is ordinarily in charge of the man who operates the log lift. It is his duty to keep a supply of logs ready for the sawyer. He also inspects each log to see that it does not contain rocks, dog points, or other material which will dull or scratch the saws. Where the logs are scaled to determine roughly the output of the mill, the scaling is done by the deckman. In large plants it is frequently assigned to a man who does nothing else.

LOG STOPS AND LOADERS

Log stops and loaders are used to detain the logs at the foot of the inclined deck until the sawyer is ready for a new log on the carriage. A typical stop is shown in Fig. 7. The stop consists of hooked arms with curved bases, fastened at the center to a horizontal shaft running across the deck parallel to the carriage track. When the stop is at rest the hooked part of the arm extends from 12 to 18 inches above the deck skids and effectively holds the log. As soon as the sawyer is ready for a new log, he admits steam into the cylinder by moving a lever. This forces the base of the stop up and the arm down, permitting the first log to pass to the carriage and detaining the next, temporarily with the base and permanently with the hooked arm, which comes up as the base is lowered.

Log stops are made in various sizes for handling large, medium, and small logs. The three sizes most used at fir mills are shown in the following statement of costs.

COSTS OF LOG STOPS (1916)

Size of cylinder, in.	Size of shaft, in.	3-arm Weight, lbs.	3-arm Cost delivered, $	4-arm Weight, lbs.	4-arm Cost delivered, $	5-arm Weight, lbs.	5-arm Cost delivered, $
14	$3\frac{7}{16}$	3,000	300.00	3,500	350.00	4,000	400.00
16	$4\frac{7}{16}$	6,000	400.00	7,000	475.00	8,000	550.00
18	$5\frac{7}{16}$	7,000	500.00	8,500	600.00	10,000	700.00

These costs are for complete stops and loaders with cylinders, bell cranks, levers, boxes, and the usual amount of shafting. The cost of installation is from $50.00 to $60.00.

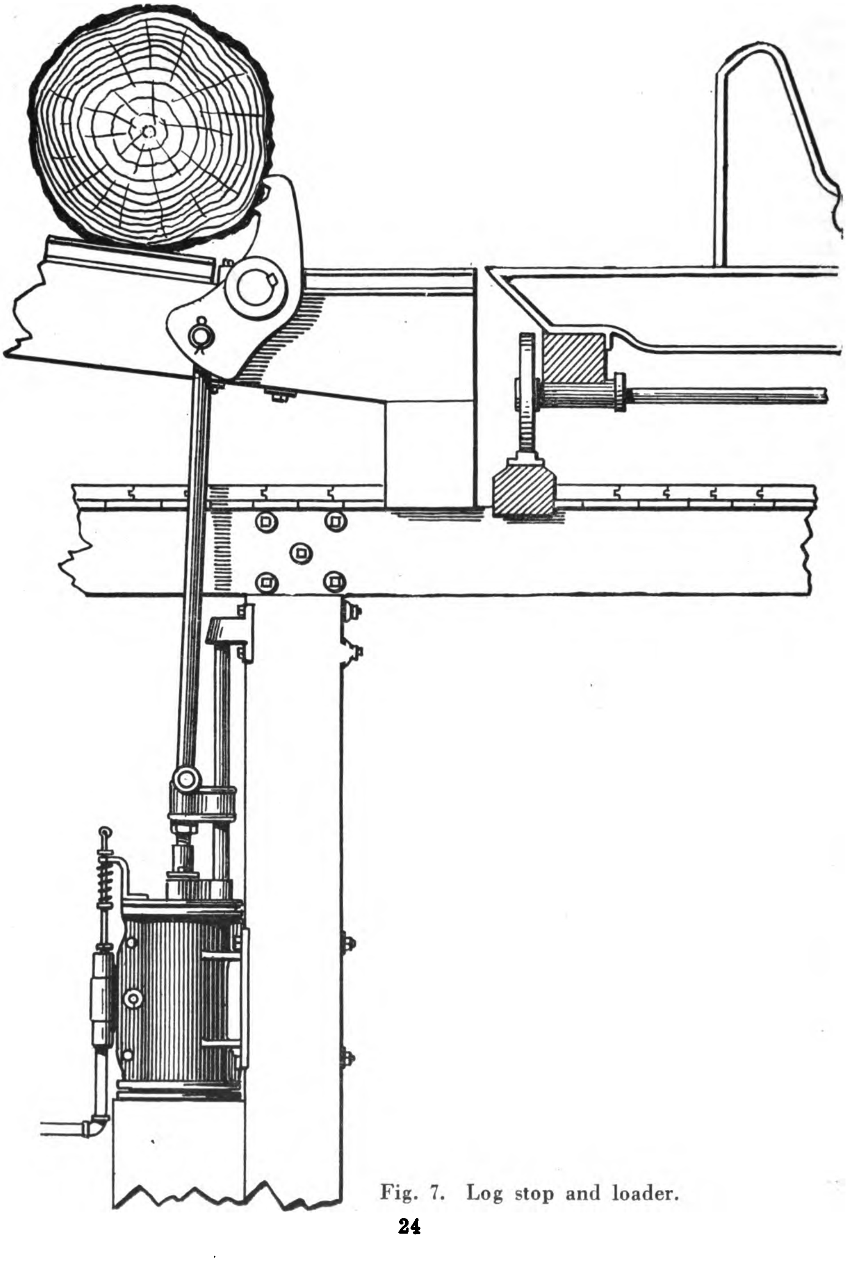


Fig. 7. Log stop and loader.

LOG TURNERS

As the name implies, log turners are used to change the position of logs on the carriage to permit squaring them up and obtaining as much wide, clear lumber as possible by taking the boards from the surfaces of all four sides before breaking the squared timbers into desired thicknesses for re-sawing. Since the amount of time required in turning the log affects the output of the mill, it is essential that the turners be designed to operate as rapidly as the weight of the logs will permit.

There are three types of log turners in use at Douglas fir mills, Simonson turners (Fig. 8), niggers (Fig. 9), and overhead turners (Fig. 10). In choosing a turner for Douglas fir mills, it is necessary to keep in mind the diameter and length of the logs to be handled, since each of the turners is best suited to logs of certain sizes, although they can be used on logs of practically any dimensions. Sometimes all three are installed in the same mill.

The Simonson turner is the one usually employed in the larger and more efficient Douglas fir mills, since it is designed to handle large, long, and heavy logs with great rapidity. It is the only type of turner which turns the logs away from the carriage knees, and thus causes less wear and tear on this portion of the equipment. The power is supplied by two rocking horizontal cylinders, from 10 to 14 inches in diameter and from 5 to 6 feet long (depending upon the size of logs for which the turner is to be used), placed on the floor of the deck just below the level of the deck skids. The position of the turner in the mill is shown in Fig. 4. The piston rod of one cylinder is connected to an elbow by a hooked arm in such a manner that as the piston rod advances the arm is unfolded and the hook at the tip of the arm thrown over and caught on the top of the log. The other end of the elbow is arranged to turn freely upon a heavy shaft running parallel to the carriage rails beneath the deck skids. The piston rod of the second cylinder is connected to the extreme end of one of several push arms keyed to this shaft.

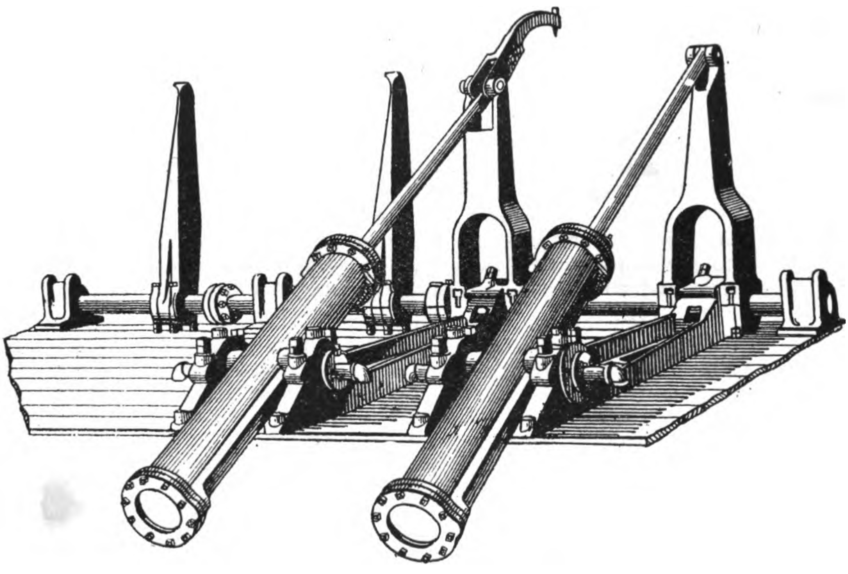


Fig. 8. Simonson type of log turner.

To turn a log, the sawyer by means of a single lever admits steam to the first cylinder, which advances the piston and unfolds the elbow arm, throwing the hook upon the top of the log. Steam is then admitted to the other end of the cylinder and the piston rod recedes, drawing the hooked arm back and pulling the log down upon the deck skids. At the same time that the log drops upon the deck skids the sawyer, by moving the lever at another angle, admits steam into the second cylinder, causing the piston rod to advance and moving the group of arms against the log. This slides the log back upon the carriage in position for cutting. As the log falls upon the deck, special steam skids are raised enough to permit the log to slide back upon the head blocks without catching on the nose of any one of them. The original method of raising these skids was by means of an eccentric cam attached to the horizontal shaft, but since this limited the raising of the skids to times when the turner shaft was moved to a definite position it was not very effective. The recent improvements in the construction of these machines provide for independent skids which are operated by a foot lever.

The following table gives the weights and costs of Simonson log turners of typical sizes. The number of arms necessary depends upon the length of logs to be handled, and the size of the cylinders upon the weight or diameter of the logs.

WEIGHTS AND COSTS OF LOG TURNERS (1916)

Size of cylinders, in.	Number of arms	Maximum size of logs: Diameter, in.	Maximum size of logs: Length, ft.	Approximate weight, lbs.	Cost delivered, $
10	3	72	24	8,750	1,200
10	4	72	50	10,150	1,330
10	5	72	66	10,750	1,575
12	3	84	24	16,500	1,950
12	4	84	50	20,000	2,325
12	5	84	80	21,750	2,525
14	5	96	80	27,750	2,975

These prices are for complete equipment with boxes and shafting, but do not include the cost of independent steam lifting skids (Fig. 3). Three such skids, weighing approximately 4,200 pounds, cost $500; four skids, weighing 5,400 pounds, cost $550; and five skids, weighing 6,000 pounds, cost $650.

The steam nigger is common in pine mills, but has not been extensively used in Douglas fir mills because it is not suitable for handling long and heavy logs. It is not only difficult to handle such logs with a nigger, but the teeth take a chunk out of the side of the log or cant, causing unnecessary waste, particularly in the clear wood. Steam niggers, however, have a place in fir mills for handling small and short logs; and in modern mills designed to cut all sizes of logs a nigger is usually installed for that purpose. This gives the sawyer an opportunity to use whichever type of apparatus is better suited to the work at hand and has the added advantage of preventing shut downs, should either piece of equipment be disabled.

Like the Simonson turner, the nigger is operated by the sawyer. To turn a log, the sawyer admits steam into the front cylinder, which raises the nigger, and as it is raised he admits steam into the back cylinder, which holds the nigger against the log, causing the teeth to engage in the face of the log and turn it against the knees. The nigger can also be used to hold the log against the knees while it is being fastened to them and made ready for the sawing operation.

Of the two sizes of niggers for which prices are given below, the smaller is more used, since most of the niggers installed at present in the fir region are used in conjunction with Simonson turners and are designed to take care only of the smaller and medium-sized logs.

The niggers with 10" and 12" cylinders (the smaller is that toward the log carriage) will lift 9 tons with 100 pounds gage steam pressure. Niggers with 10" and 12" cylinders weigh 5,270 pounds and cost $550; and those with 12" and 15" cylinders weigh 6,820 pounds and cost $650.

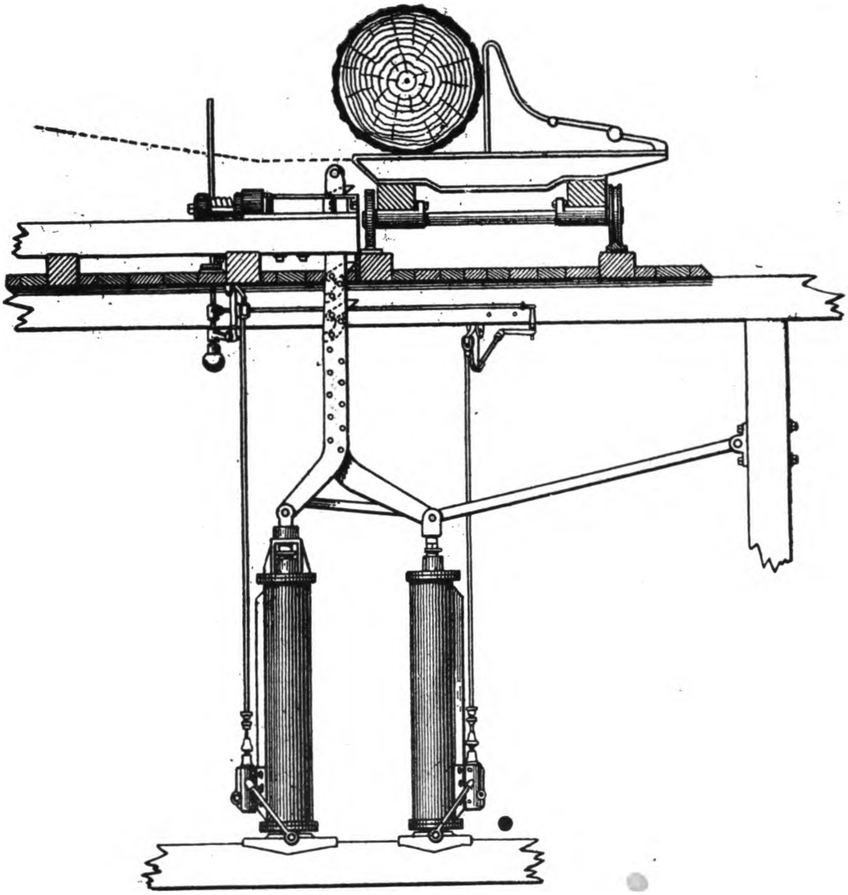
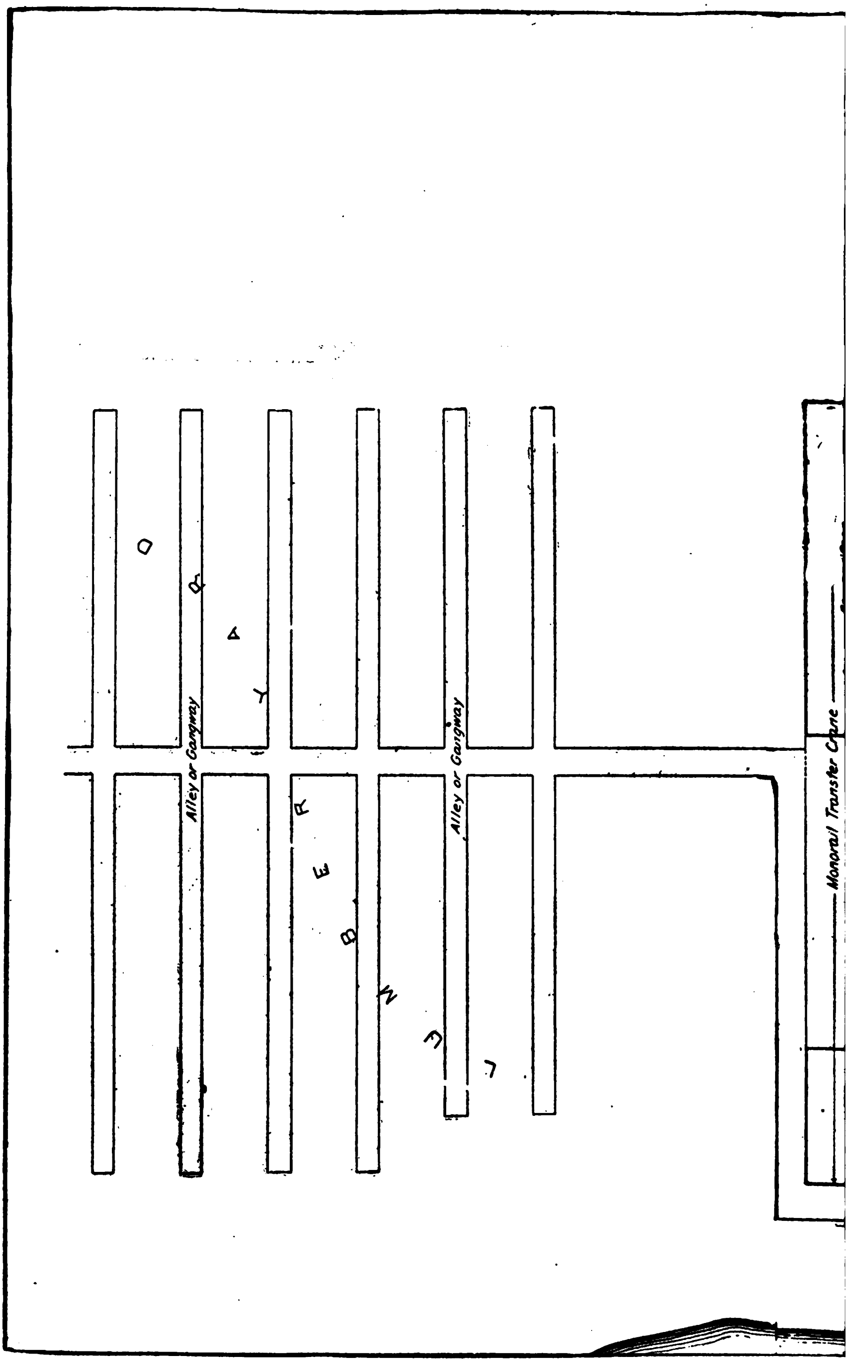


Fig. 9. Steam nigger type of log turner.

These costs include a spring floor plate or guide to control the action of the nigger and prevent it from damaging the deck and carriage. The plate can be seen in Fig. 9 resting on the floor timbers. The estimated cost of installing steam niggers is about $50.

The old style of overhead log turner, or canting gear as it is frequently called, is still employed in many mills as an emergency turner for handling extra heavy logs, or for use when the other turners are out of order. This type of turner is slow and cumbersome, but it is still used to some extent in small mills.

The apparatus (Fig. 10) consists of a drum and chain geared to a shaft which is turned by a beveled friction drive. Spur-geared drives are also used, especially in shaft-driven mills. The entire mechanism is mounted upon the girders directly above the carriage, and the chain is raised or lowered by the operation of a lever placed within the sawyer's reach. At the


Alley or Gangway
Alley or Gangway
Monorail Transfer Crane

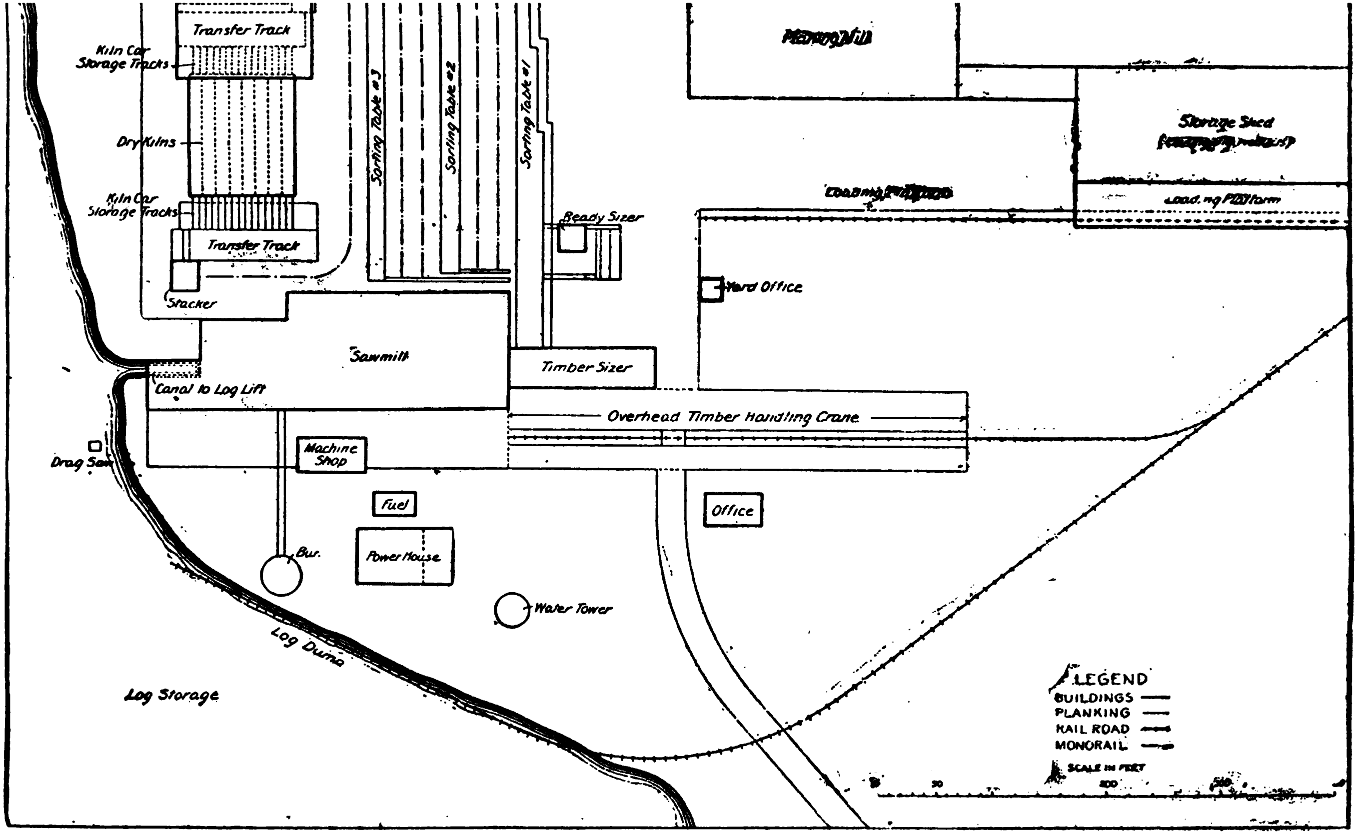


Fig. 2. General plan for large lumber manufacturing plant in the Douglas Fir region.

end of the chain is a hook which grasps the log. To turn the log the chain is lowered and wrapped around it; then, by reversing the gear, the chain is raised and gradually unwound, causing the log to turn to any desired position. The best gears are equipped so that the chain may be lowered rapidly, even though the hoisting is done slowly. The principal advantage of this type of turner is that the logs are not badly damaged in turning and there is less wear and tear on the carriage and mill than where niggers or Simonson turners are used, since the jarring and pounding is practically eliminated.

Overhead turners are built in a variety of sizes, according to the amount and weight of the chain to be used, which in turn depends upon the size of logs to be handled. A representative turner weighs about 3,000 pounds and costs approximately $275 (1916), including chain, boxes, and usual parts.

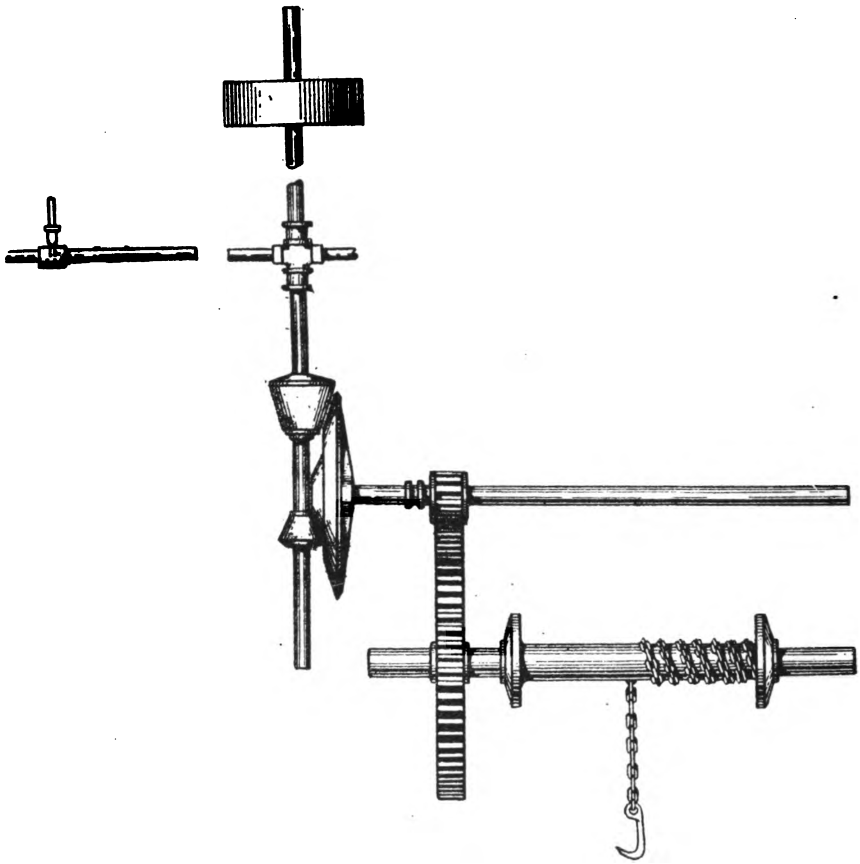


Fig. 10. Overhead type of log turner.

ROCK SAWS

When logs are received at the mill covered with grit, gravel, and other foreign material as a result of "driving," a rock saw is usually employed to clean a path in the cutting line of the band saw. This practice prevents unnecessary wear and tear on the band and increases the cutting life of the teeth.

The rock saw is hung at the end of a counter-weighted arm suspended above the log carriage parallel to the log. The saw and arm are raised or lowered for logs of various sizes and for taper and other irregularities. It is operated by a boy, who pulls the saw down into the cut or allows it to rise to obtain the desired position. The sawdust thrown off from this saw is removed through a "blower pipe" similar to that employed for carrying away planer shavings. These rock saws complete with countershaft and pulleys, but exclusive of the motor and blower, cost approximately $100.00.

The saw is usually from 24 to 26 inches in diameter, 3 gauge, and has a kerf of ⅞ of an inch. Because of this wide kerf, it is the duty of the rock sawyer to prevent the saw cutting into the wood proper, the cut being made through the bark only.

A 15 horsepower motor is ordinarily required to operate the saw. The following are representative figures for power demand:

	Kw.	H. p.
Input running light	3.5	4.7
Maximum instantaneous input	34.0	45.5
Sustained input during cut	10.0	13.4
Average input throughout day	4.85	6.5

An additional 15 horsepower motor is required to run the 35-inch centrifugal blower fan which removes the sawdust. The power demand for such a fan run at 2,300 r. p. m. is as follows:

	Kw.	H. p.
Maximum input	15.2	20.4
Minimum input	11.0	14.7
Average input	11.55	15.4

The cost of blower fans and piping for use in this class of work is given under the discussion of blower systems.

A 15 h. p. motor, of 550 or higher voltage, billed complete with base, pulley and starting compensator weighs about 1,120 pounds and costs approximately $350 (1916).

LOG CARRIAGE

The log carriage is the vehicle upon which the log is passed against the head saw in the main sawing operation (Figs. 4, 5 and 11). The carriage proper consists of three essential units,—the frame and trucks for supporting and conveying the equipment and log, the blocks. knees, and dogs for holding the log, and the set works for advancing the log for the desired thickness of cant to be cut.

The frame is made from 32 to 50 feet long, depending upon the average length of the logs—trailers are used for extra long logs. The representative carriage length in the fir region is 40 feet. The width (over all) varies from

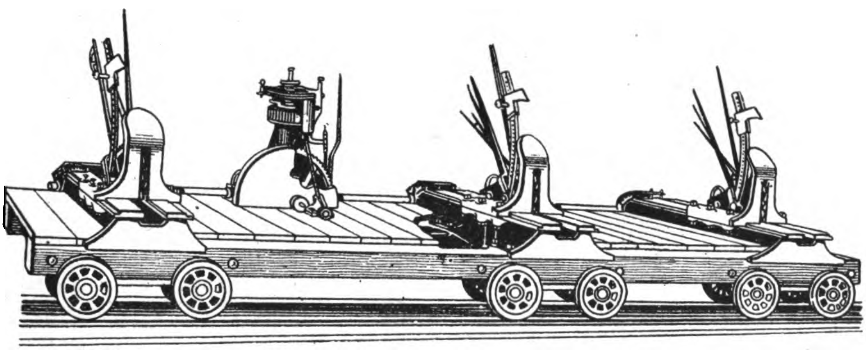


Fig. 11. 72 in. by 32 ft. three-block log carriage.

8 to 11 feet according to the maximum diameter of logs to be cut, 10 feet being the usual. The frame is ordinarily of wood and can be made at the plant during the construction of the mill. Steel carriage frames can be purchased, but they are much more costly and less resilient than those of wood.

The trucks are cast steel, each set having two axles with either 2, 3 or 4 wheels (14 to 18 inches in diameter) on each. One set of trucks is placed under each block. The ordinary diameter of carriage wheels is 16 inches, and there are usually three to the axle, since a three rail carriage track is most often used. The rear wheels, which are grooved to fit the rear rail, hold the carriage on the track and retain a straight cutting line.

In single cutting band mills the trucks are equipped with an automatic offset device which shifts the carriage frame back on the axles half an inch or so away from the cutting line to prevent striking the saw on the return or non-cutting stroke. A control lever operated by the setterman prevents this offset in backing out of the cut when a false start is made.

The bolsters or skids upon which the log rests are called blocks. They are divided so as to encase a screw used in moving the knees, which latter they also support and guide. The size of the carriage is measured by the length of the blocks, or rather, the distance between the cutting line and the face of the knees when moved back the maximum distance on the blocks. This ranges from 60 inches to 84 inches, but the prevailing is 72 inches. From 3 to 5 blocks are used on the main carriage and one on each trailer. Thirty-two foot carriages have 3 blocks; forty foot, 4; and fifty foot, 5. The distance between the blocks varies to accommodate the variety of log lengths to best advantage. The following are typical: between blocks (center to center) 1st and 2nd—11 feet, 2nd and 3rd—11 to 12 feet, 3rd and 4th —12 feet, 4th and 5th—12 feet; first trailer 12 feet, second trailer 14 feet.

To obtain the maximum length of log a certain number of blocks will cut, add the distances between the blocks and increase the total by about 12 feet.

The knees are the upright stops against which the log rolls when put on the carriage and against which it is held during the cutting operation. Each individual knee may be moved several inches either way out of line to take care of taper or any irregularities in the surface of the log and all may be advanced or moved back simultaneously by means of the set works so that the log remains parallel to its original position.

The knees are from 12 to 24 inches high, the prevailing height being 16 to 18 inches. Where steam niggers are used in turning the logs, a hook is often placed on the top of each knee to prevent accidentally getting the log behind the knees, and the tops of the knees are beveled (sometimes rollers are inserted in the top) to avoid getting the logs hung up. Low knees, 12 inches high, are coming into general use because they reduce the leverage and thus the shock when large logs strike the top of the knees in rolling upon the carriage. They also increase the capacity of the blocks because large logs can overhang the short knees.

Most knees are equipped with two or three kinds of dogs for holding the log, cant, or board firmly against them to insure perfect lumber. The main or "hook dog" is used for holding the log and cants from above when a curved face is presented to the knee. This is usually supplemented by a smaller dog operating from below. Some knees are equipped with multiple-tooth "board dogs" which project from the face of the knee and are used in making the final cut when only slight projection is possible. This can be accomplished, however, by careful manipulation of the two dogs mentioned above.

The set works is the part of carriage equipment through which the setterman mechanically advances the knees an amount equal to the thickness

of the cant to be cut, or moves them back to make room for turning a log or receiving a new one. There are many types and makes of set works, but most of those used on the Pacific Coast are of ⅞ or 1-inch manila rope drive, although electric motors are now being very successfully used for this work.

To advance the log for making 2 inch stock, the setterman moves the indicator handle to 2 inches on the dial and brings the automatic trip lever up against the indicator. At the instant he desires to advance the knees, he pulls the set lever which puts the setting friction clutch in action until the automatic trip lever releases and stops it when the knees are advanced two full inches. These setworks are made to set accurately and automatically by $\frac{1}{16}$" increments.

COST OF CARRIAGE PARTS (1916)

Part	Weight, lbs.	Cost delivered, $
72 inch blocks each	2,500	250.00
Board dogs	150	45.00
Hook dogs	125	30.00
Trucks—each block	1,500	100.00
Offsets—each truck	600	65.00
Setworks	6,000	900.00
Each trailer	5,250	550.00
Carriage track rail (per ft.)	13	0.60
Buffers—each	1,400	120.00

Motor driven setworks are in use at some electric plants. Power records of a 4 block 72 inch carriage are given below.

Average input throughout day	2.8 Kw.
Maximum instantaneous input	14.4 Kw.
Running light	2.4 Kw.
Average input during operation of setworks	6 Kw.

The duration of load is from ½ to 3 seconds at intervals of from 15 to 20 seconds.

A 7.5 horsepower set works motor weighs 300 pounds and costs, delivered, $115; a 10 horsepower motor weighs 380 pounds and costs $142; and a 15 horsepower motor weighs 550 pounds and costs $190, (1916).

CARRIAGE ENGINES

In Douglas fir mills the carriage is usually driven by means of vertical twin cylinder steam engines Figs. 4 and 5 instead of the shot gun (direct piston) feed so common in the pine mills. By moving the control lever forward or backward a given amount, the sawyer admits steam to the cylinders at a rate to give the desired speed of travel (forward "feed" and backward "gig").

The size and cost of carriage engines depends upon the size of carriage and logs to be handled. Most operators prefer a large and powerful engine for such work, since it insures rapid work and maximum output.

SIZES AND COSTS OF ENGINES OF TYPICAL SIZES

Size of cylinders, in.	Weight, lbs	Cost delivered, $
11 x 14	5,500	700.00
12 x 16	6,000	800.00
13 x 18	8,000	950.00
14 x 18	8,500	1,025.00
16 x 20	14,000	1,500.00

These costs include sheaves, boxes, and fittings but no cable. The cost of the cable is from 20 to 25 cents per linear foot. The amount necessary is twice the length of the carriage track, plus from 30 to 40 feet for winding around the sheave.

HEADSAWS

The headsaw is so named beause it is the chief factor in reducing the log to lumber and the first saw with which the log comes in contact in the mill. It removes the rounded surfaces from the log and reduces it to flat pieces of desired thickness. These pieces are later reduced to proper board widths and lengths by the machines used for edging and trimming respectively.

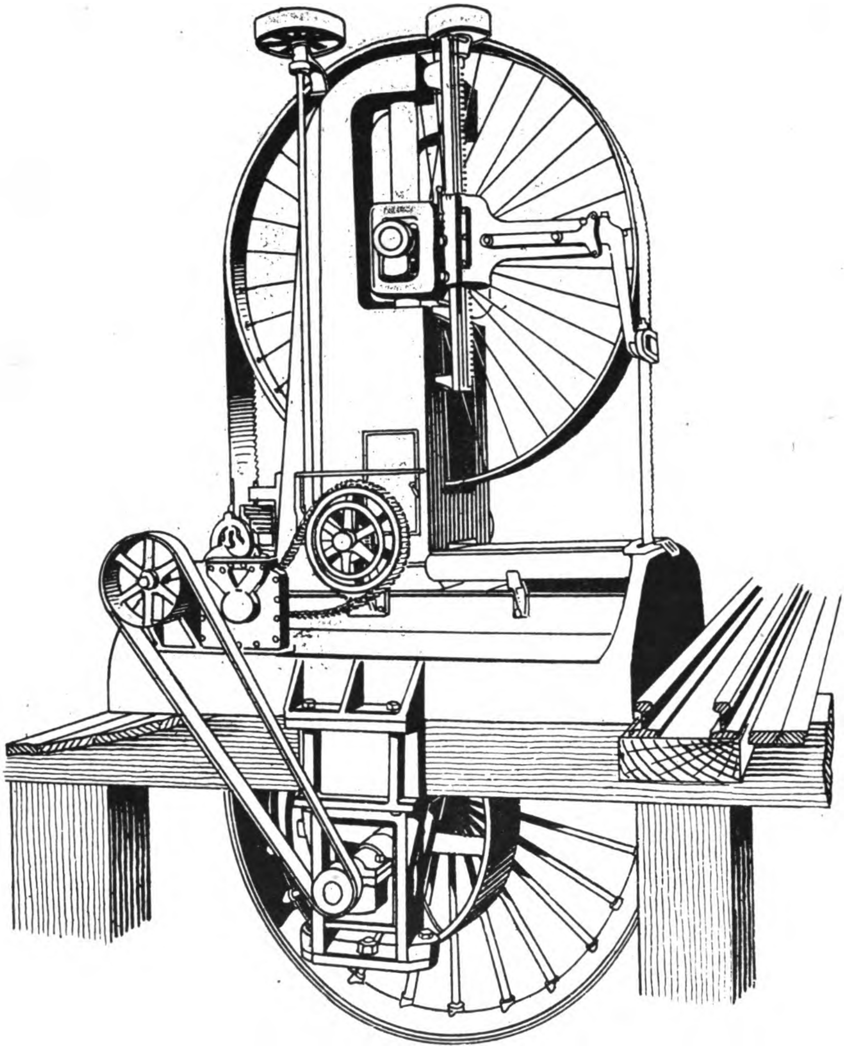


Fig. 12. Left hand single-cutting band headsaw, 10 ft. wheels.

TYPES

There are two types of headsaws in general use in the Douglas fir region, the band and the circular.

The band saws are of single and double cutting types. The single cutting type saws only as the log carriage moves forward, while the double cutting

type saws during both motions of the carriage. The double cutting type can produce approximately from 20 to 25 per cent more lumber in a given period, but it has not come into general use in this region for several reasons. Theoretically, there is no mechanical reason why the double cutting saw should not operate as efficiently as the single cutting type. There has been some difficulty, however, in producing uniformly good lumber on headsaws of this kind. The length of the logs in the fir region makes it more difficult to cut lumber accurately than where shorter logs are used, as in the pine regions. From the standpoint of quality of lumber obtained the principal objections to the double cutting headsaw is that the sawyer does not get an opportunity to examine the face of the board before each cut. Where single cutting saws are used this is done as the log passes the sawyer in returning for the next cut.

A band headsaw consists of a heavy base and frame (Figs. 4, 5 and 12) supporting two pulley-like wheels over which the vertical saw runs belt fashion. The upper wheel is of lighter design than the lower, which is made heavy to steady the mill and give it a fly-wheel effect, keeping the load more uniform. The lower wheel is also the "driver," thus drawing the saw down into the cut. The saw is kept taut and in a straight vertical line by special counterweighted straining devices on knife-edge supports which also cut down vibration. The journals of the upper axle are movable to permit loosening and removing the saw, as well as to accommodate varying length of saws. In addition to the straining device for aligning the saw, guides are used above and below the cutting zone. The lower guide is stationary, while the upper one is movable to accommodate logs of different diameter.

There are also two types of circular headsaws—single and double. The single is used mostly by mills operating in small timber. The double is the standard type for all other mills in the region. The double type is composed of two saws, one placed above the other and in the same vertical plane (Fig. 13), thus making possible the cutting of logs approximately twice as large as those which can be cut on a single saw. The simplicity of design and operation of circular headsaws makes them very popular among small operators who cannot use or afford elaborate cutting equipment.

ADVANTAGES OF BAND HEADSAWS

1. The waste in saw kerf is only $\frac{3}{16}''$ to $\frac{1}{4}''$ instead of $\frac{13}{32}''$, or about half as much with a band as with a circular headsaw. From actual tests this waste has been found to amount to from 5 to 16 per cent, with an average of approximately 10 per cent of the total log scale cut. Assuming that logs are worth $9.00 per thousand, this loss amounts to $90.00 per day in actual cash in a mill cutting 100,000 feet per day. There is an additional loss in producing capacity of the mill through extra time required to handle the additional logs necessary to obtain the same quantity of lumber a band saw will produce in a given period, but lack of data prevents a calculation of its amount.
2. The band saw requires less installed power than the circular.
3. The annual cost for saws is less, because of the enormous number of teeth required for circular saws operating in Douglas fir.
4. Larger logs can be sawn without special equipment.
5. Wider boards can be cut.
6. Band cut boards wider than 27 inches are smooth, while such boards from circular saws are frequently ribbed where the two saws overlap. Sometimes the alignment is off as much as ½ inch. It is almost impossible to keep both saws in proper tension to insure cutting in exactly the same plane.
7. Band saws are said to be operated successfully at higher speed than circulars, which, it is claimed, gives them greater cutting capacity. This opinion has been disputed, however.

ADVANTAGES OF CIRCULAR HEADSAWS

1. The initial cost is much less for circular than for band saws. This is a very important factor in the construction of small mills.
2. Only about one-half as much need be paid out in wages for filing and tensioning.
3. The cost of file-room equipment is almost negligible.
4. The adjustment and operation require much less skill to produce uniformly good lumber, and there is less damage to the saws where logs accumulate gravel and rocks in driving.
5. Circular headsaws are portable and adapted to operating in small isolated tracts of timber. They are easily and quickly set up.

SIZE, CAPACITY AND COST

Circular headsaws vary in the Douglas fir region from 56 inches to 60 inches in diameter. The upper saw of the double circular is sometimes smaller than the lower saw, but not usually because the large fir timber requires the maximum width of cut. It is also advantageous to have these saws interchangeable.

The maximum width of boards and the diameter of logs which can be cut on circular headsaws of different types is as follows:

CUT OF CIRCULAR HEADSAWS

Size of saw, in.	Type	Width of widest board, in.	Diameter of largest log, in.
56	Single	25	31
56	Double	49	61
60	Single	27	33
60	Double	53	66

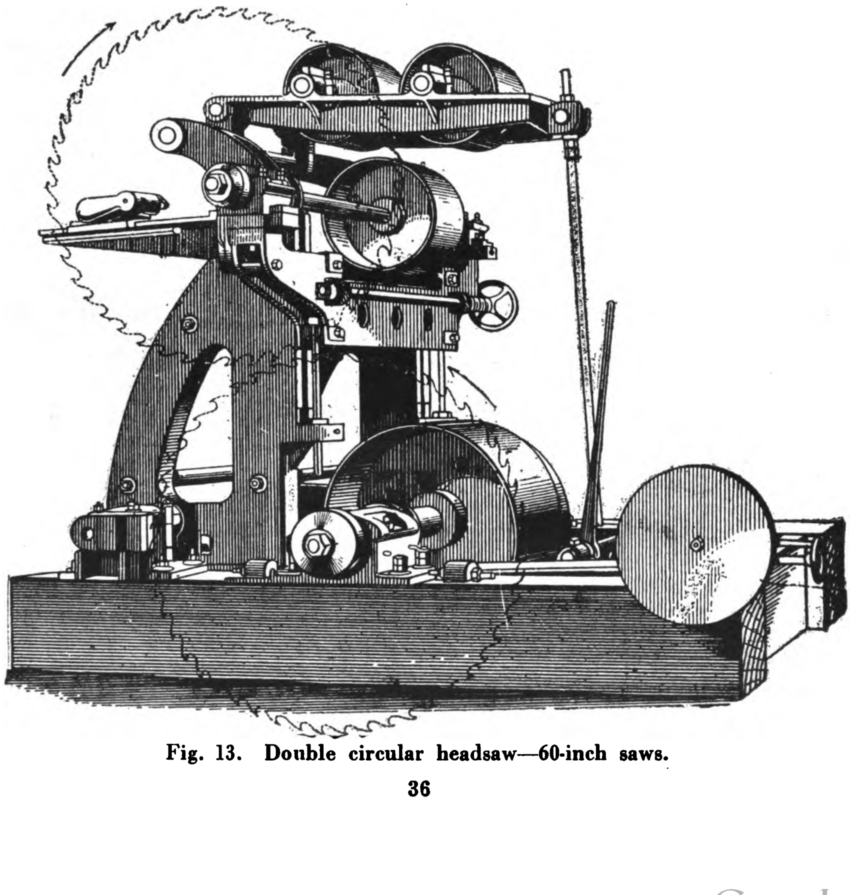


Fig. 13. Double circular headsaw—60-inch saws.

Circular headsaws have a producing capacity of from 10,000 to 250,000 feet per ten hour day, depending principally upon the auxiliary sawing equipment, the size of the logs, the speed of the feed, and the available power. The lower extreme is that of the small portable mill with slow saw speed, a hand edger, and a hand trimmer, cutting short logs, and operated with very little power. The higher extreme is the circular headsaw used to slab or "break down" logs for a double cutting pony band resaw, or supplemented with roller and gang resaws.

The size of the band headsaws cutting fir varies from 9 feet to 11 feet, the most popular size being 10 feet, which is the diameter of the wheel upon which the belt-like saw runs. Where fast feeds are used the mills are 11 foot mills in order that heavy saws may be employed.

Single cutting band headsaws have a capacity of from 75,000 to 350,000 board feet per ten hour day, depending upon the speed of feed, the auxiliary equipment, size of logs, and available power. The reason why the lower figure is so much higher than the minimum given for circular mills is because the high cost of band mills and their operation necessitates the installation of proper auxiliary equipment to enable a good sized production and insure economic operation. Furthermore, band mills ordinarily are not portable[1], and therefore, are not adapted to operating in isolated patches of timber in a small way. The lower limit represents the type of band mill which has no resaw, and where all material, even one inch boards, are cut on the headsaw at ordinary rates of feed. The upper limit is the capacity of band saws supplemented with the auxiliary equipment mentioned under circular saws.

A 9 foot band headsaw machine weighs from 38,000 to 42,000 pounds and costs from $2,800 to $3,200 (1916); and a 10 foot band machine weighs from 54,000 to 58,000 pounds and costs from $3,800 to $4,200 (1916).

The above figures include steam or friction operated guides, straining devices, and belt tighteners. Ten per cent should be added to the cost and from 1,200 to 1,600 pounds to the weight to cover the belt ordinarily used to drive these machines. The cost of installing band headsaws is from $100 to $150.

SPEED OF FEED

The speed of feed employed in sawing Douglas fir logs of the same size is not uniform, even among plants using the same equipment, and varies from less than 1/32" to 1/6" per tooth. The average feed for the general run of log is probably close to 200 linear feet per minute for the region as a whole, while the maximum average feed known to the author is close to 500 feet per minute, and the maximum on small logs is 650 feet per minute. For the average run of fir logs a feed of 500 linear feet per minute will yield approximately 10 board feet of lumber per second, including time lost in changing and turning logs, changing saws, and normal delays.

STRAIN FOR BAND SAWS

In order to keep the cutting edge of the saw running true and to stiffen the saw so that it will not be pushed off the wheels upon entering the cut, special straining devices are employed. Insufficient strain destroys the purpose of such devices, while too much strain overloads the saw and may cause cracks or even breaks. The following figures applied by saw manufacturers show the recommended strain for Douglas fir band headsaws of various widths and gauges:

[1] A small portable band mill has recently been placed on the market and is said to cost only $3,000 complete with carriage, engines, boiler, etc.

STRAIN RECOMMENDED FOR BAND HEADSAWS

Width of saw, in.	Gauge of saw	Strain, lbs.	Width of saw, in.	Gauge of saw	Strain, lbs.
12	13	12,300	14	12	16,700
13	13	13,300	15	12	17,700
14	13	14,400	16	12	18,700
15	13	15,400	15	11	21,500
13	12	15,600	16	11	22,500

The following formula developed by Mr. C. G. Blagen, of Hoquiam, Washington, is said to give excellent results, and is applicable to saws which have been cut down beyond the widths shown above: "Take the thickness or gauge of the saw in thousanths of an inch, disregarding the decimal [1]. Multiply this by the width of the blade[2], and then multiply this product by a constant of 8 for the minimum strain or by a constant of 10 for the maximum strain[3]."

SPACING OF SAW TEETH

Circular headsaws used in cutting Douglas fir have an average tooth space (distance between the teeth points) of about 4½ inches. A few operators use a space of 4¾ inches.

For band headsaws a tooth space of 2½ inches is most common, although many mills are using a 3-inch space for heavy work.

The tooth spacing is regulated mainly by the speed of the saw, the speed of feed, and the nature of the wood being cut.

SPEED OF SAWS

The speed at which band and circular saws are operated has a bearing upon the cutting capacity of the machine, and is an important feature of sawmill management. Operators do not agree on the proper speeds for saws cutting in the same wood, and for this reason it is rather difficult to give definite values. The figures given below for band saws and circular saws represent averages rather than speeds which are actually known to be the best for Douglas fir.

Saw makers and the best sawyers operating in fir agree that 9,000 feet per minute at the rim is probably the best speed for true, smooth cutting with circular saws. Headsaws operated at higher speeds are sensitive and inclined to wabble in cutting. For this reason they are also more likely to heat. On the other hand, slower speeds reduce the rate of feed possible and are otherwise objectionable.

A speed of 9,000 feet per minute is equivalent to about 620, 590, and 570 revolutions per minute for 56-inch, 58-inch, and 60-inch saws, respectively.

The speed of band saws in the Douglas fir region varies from 9,000 to 11,000 feet per minute, but most of them are operated at the average speed of 10,000 feet per minute. The speed of 10,000 feet per minute is equivalent to 355 revolutions per minute for 9 foot headsaws, 320 for 10 foot, and 290 for 11 foot.

SIZE AND COST OF SAWS (1916)

Band mill manufacturers recommend the use of saws only one foot longer than the shortest saw the mill will take, since this reduces the distance between the saw wheels and makes it easier to keep the saw running true. Below is given the size and cost of band saws.

SIZE AND COST OF BANDSAWS (1916)

Size of mill, ft.	Length, ft.	SAW — Gauge	SAW — Width, in.	Kerf, in.	COST — Single cut per foot, $	COST — Double cut per foot, $	Weight per foot, lbs.
9	50-54	13	14	$\frac{5}{16}$	3.15	3.50	4.50
10	57-60	13	15	$\frac{3}{16}$	3.85	3.85	4.82
11	63-67	12	16	$\frac{7}{32}$	4.50	5.00	5.92

[1] Multiply the thickness of the saw in thousandths of an inch by 1,000.
[2] In inches.
[3] In pounds.

The present tendency among fir operators is to use thinner and narrower saws than was the custom several years ago. Twelve gauge saws were formerly in extensive use on ten foot mills, but now nearly all are thirteen gauge. This is probably because thinner saws are more flexible, and hence less likely to crack. They also require less kerf to keep from binding. Saws 17 inches, 18 inches, and even 19 inches wide were used quite generally several years ago because the operators thought they would have a longer life in proportion to their cost than the narrower saws. It is said, however, that before the wide saws were worn down sufficiently to justify their being discarded, they became crystallized and brittle by constant temperature changes and tensioning. As a result, the sizes shown are now almost universal.

The size, cost, and weight of inserted-tooth circular headsaws are as follows:

SIZE AND COST OF INSERTED-TOOTH CIRCULAR HEADSAWS (1916)

Diameter, in.	Gauge	No. of Teeth	Kerf, in.	Cost F.O.B. Portland or Seattle, $	Weight, lbs.
56	5	40	13/32	99.10	200
58	5	42	13/32	110.00	220
60	5	44	13/32	121.00	250

Additional saw teeth, or bits as they are called, cost 2½ cents each, and the holders from 35 to 40 cents each.

POWER FOR HEADSAWS

The amount of power required for headsaws of any given size or kind varies with the speed of the saw, the size of timber cut, and the rate of feed used. In small circular mills where the cut is from 10,000 to 40,000 feet per day, the power requirement is low because the feed is slow. In circular and band mills cutting from 100,000 to 350,000 feet per day, the power requirement is greater because the feed is crowded to the maximum. There should be sufficient reserve power to retain the proper saw speed at all times. Too many mills are handicapped by insufficient power for the headsaw, and as a result, are operating at only from 50 to 60 per cent of their potential capacity. This applies particularly to steam, shaft-driven mills, for electric mills have a certain amount of reserve power in the overload which the motors will stand for short periods.

While in the cut, circular headsaws require much more power than band saws because the saw kerf is twice as wide and the saw is working constantly against the feed. This is especially true in wide cuts, and offsets to a certain extent the extra power required to turn the heavy band saw machinery. Running light, the circular headsaw requires about one third of the power demanded by a band saw.

There is very little difference in the power requirement of 9-foot and 10-foot band headsaws, and the data given below can be construed as generally applicable to either of these sizes. Motors now in use on these headsaws range from 200 to 300 horsepower. Under normal conditions a 250 horsepower constant speed motor is probably ample for either a 9-foot or 10-foot band headsaw cutting Douglas fir, but when fast feeds are to be used 400 or 500 h. p. motors are necessary.

The following data are representative of the power required for band headsaws operating in Douglas fir:

Duration of starting period....................	1 minute	35 seconds
Starting demand (instantaneous).............	560 Kw.	750 h. p.
Sustained input for 55 seconds during starting	240 Kw.	322 h. p.
Input running light..........................	56 Kw.	75 h. p.
Average input throughout day................	116.5 Kw.	156 h. p.
Average input during cut.....................	230 Kw.	308 h. p.
Rate of feed, average................................	180 f. p. m.	

Average Kw. hrs. per thousand feet................	8.8 Kw. hrs.
Average time in cut................................	8.9 secs.
Average time to gig................................	5.5 secs.
Delay between logs averaged per cut................	4.4 secs.
Delay between logs averaged per cut................	4.4 secs.

S'xty inch saws cutting $\frac{13}{32}$ inch kerf under the same working conditions as the band saw just shown will require approximately the following power:

Input running light.........................	16 Kw.	21.4 h. p.
Maximum input—instantaneous..............	520 Kw.	697 h. p.
Maximum sustained input....................	420 Kw.	562 h. p.
Average input throughout day...............	138 Kw.	185 h. p.
Average input sustained during cut..........	275 Kw.	369 h. p.

The size and cost of headsaw motors is as follows: Motors are of the slip ring type, complete with base, pulley, controller, and starting resistance.

SIZE AND COST OF HEADSAW MOTORS

Horsepower, h. p.	Speed, R. p. m.	Weight, lbs.	Cost delivered, $
150	600	6,600	1,615.00
200	600	8,100	1,940.00
250	600	8,200	2,800.00
300	600	14,200	3,187.00
400	450	15,000	4,140.00
500	450	20,500	4,910.00

OPERATIVES AND DUTIES

In addition to the men on the log carriage, who are indirectly connected with the headsaw operation, there are the sawyer and the off-bearer (sometimes called a tail sawyer) directly responsible for the headsaw operation.

The sawyer is the backbone of the sawmill personnel, since upon him depends both the quantity and quality of the output from each log. Given the best equipment to work with, the efficiency of the sawing operation and the output of the mill are entirely in his hands.

The sawyer's duties are manifold. Following is an account of his activities in cutting a representative log: As the empty carriage, the movement of which the sawyer controls, is returning to position in front of the log deck, the sawyer steps on a foot lever which releases the log from storage on the deck and allows it to roll onto the carriage. The operation is timed so that the log lands upon the carriage at the same instant that the latter comes to a full stop—thus no time is lost. The log is then quickly turned by means of a steam nigger or Simonson turner to a position which will group the defects in as few boards as possible, jammed back against the knees, and gripped by the dogs. The knees are then so placed that the slab removed on the first cut will not be too thick and thus contain an unnecessary amount of waste, nor too thin to yield a surface of board size on the log after its removal. All this is accomplished in less time than it takes to tell it, for the entire operation requires but a few seconds. The carriage is then started forward by the sawyer, and the first cut is made. It is the sawyer's duty to feed the log against the saw at its maximum cutting capacity in order to insure maximum output. As the carriage is returned or "gigged" for the second cut, the head sawyer studies the exposed face of the cut to ascertain what quality of lumber is to be obtained in the next "cant," for he must signal the setterman the thickness he desires. The outside portion of the log yields the clear or upper grade of lumber, and as soon as the low grades appear on the surface of the cut, the sawyer turns this flat face of the log down upon the carriage and starts cutting on another quarter of the log. This operation is usually repeated until the clear lumber has been removed from the four sides of the log. The piece remaining on the carriage is a big square timber containing the lower grades. The reduction of this last piece to various board sizes is governed entirely by orders or stock requirements for various thicknesses.

Since most plants are now equipped with resaws (Figs. 14 and 15), the stock is usually cut double thickness on the headsaw in order to save time, and is divided into proper board thicknesses on a resaw. Cants are also cut four inches or six inches thick, representing the width of certain planing mill stock. These are reduced to boards one inch thick and four or six inches wide on gang resaws (Fig. 15). This practice also saves much time and materially increases the capacity of the head saw. Some mills are equipped with pony resaws which are in reality headsaws used for sawing cants instead of logs. Where a mill is thus equipped, the sawyer removes only the slabs and some of the clear from the log on the headsaw, and sends the remaining portion to the pony resaw to be cut up in the same manner as described for the headsaw.

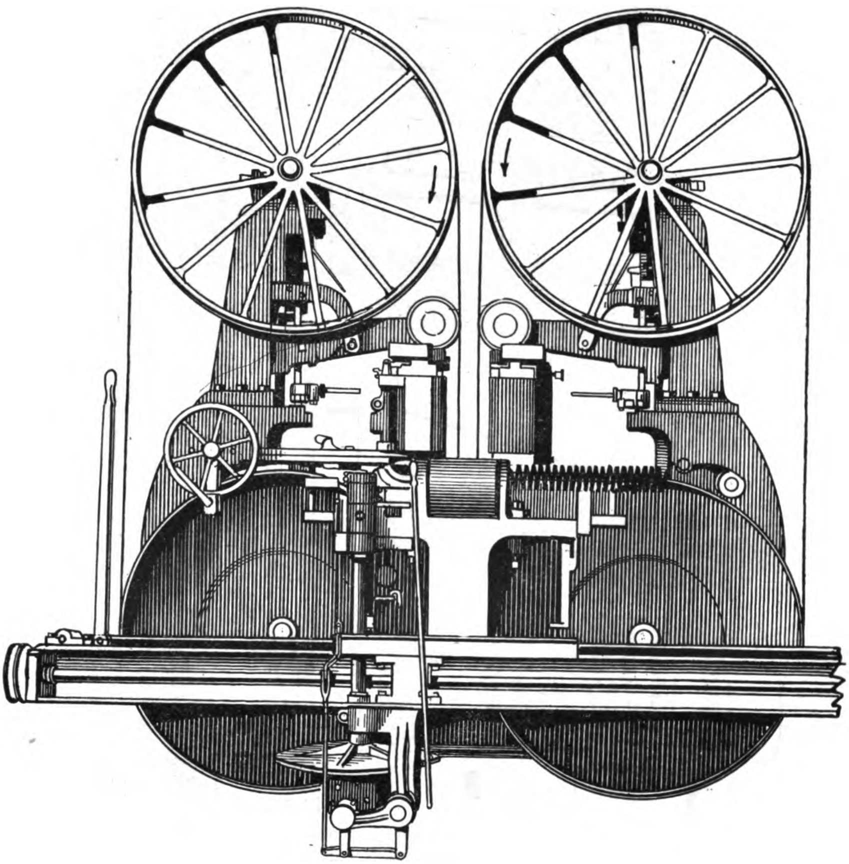


Fig. 14. Twin band vertical resaw, 60-inch wheels.

As previously stated, the sawyer must make known to the setter the thickness he wishes to cut each cant. To do this by voice is impossible because of the noise of the mill machinery and saws. To meet this condition, sawyers and setters have developed a sign language similar to that used by the deaf and dumb (Fig. 16).*

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* From the West Coast Lumberman.

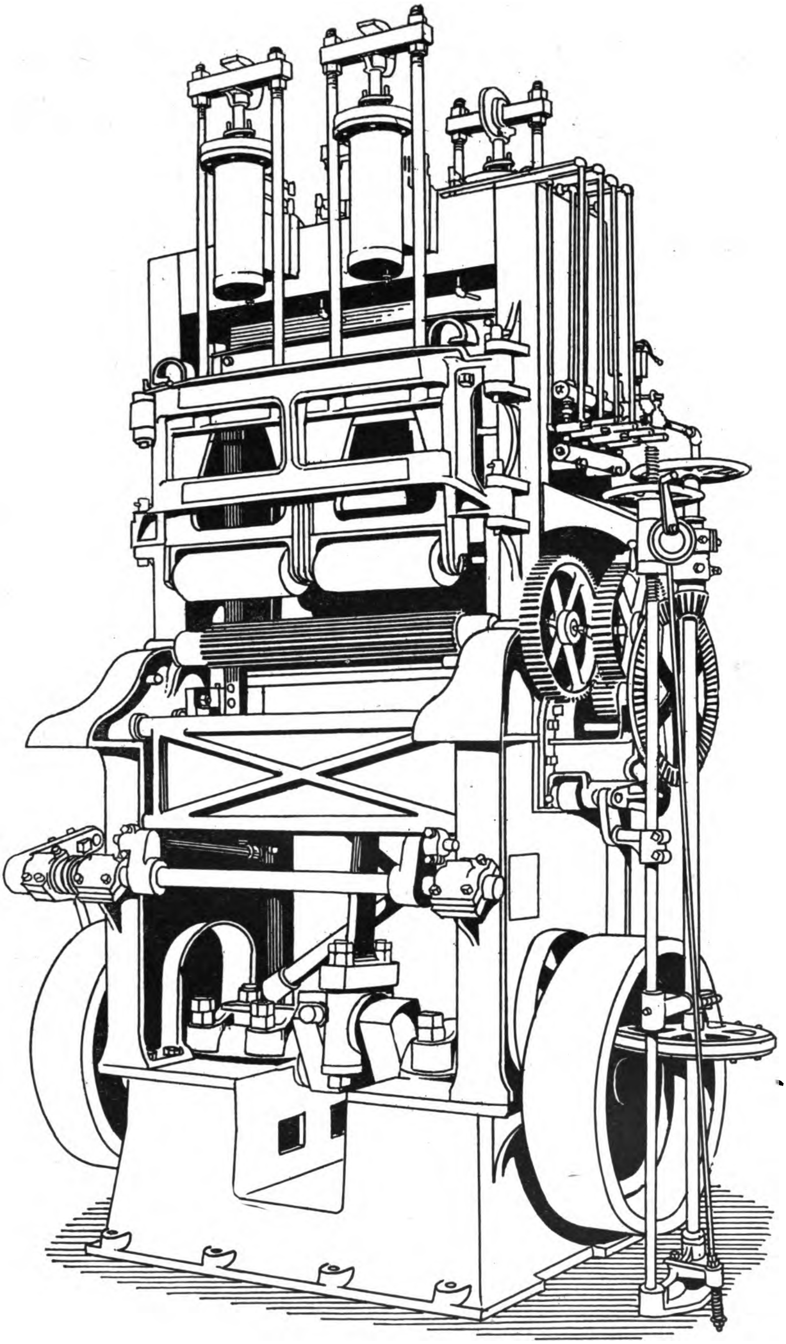


Fig. 15. Large gang saw for cants up to 14 x 18 inches.

The lower illustrations showing the fractions are given as examples of how the signs are combined. In some cases it is not possible to give these signs in one movement, wherefore there are combinations. For instance, 3¼ cannot be given at one time as the three first fingers represent three, and the little finger a quarter, so given at the same time would be four; it is given, therefore, by first giving the sign of three, then closing the three fingers and raising the little finger for a quarter. Three quarters following any unit is given by first giving the sign of three, then following with little finger.

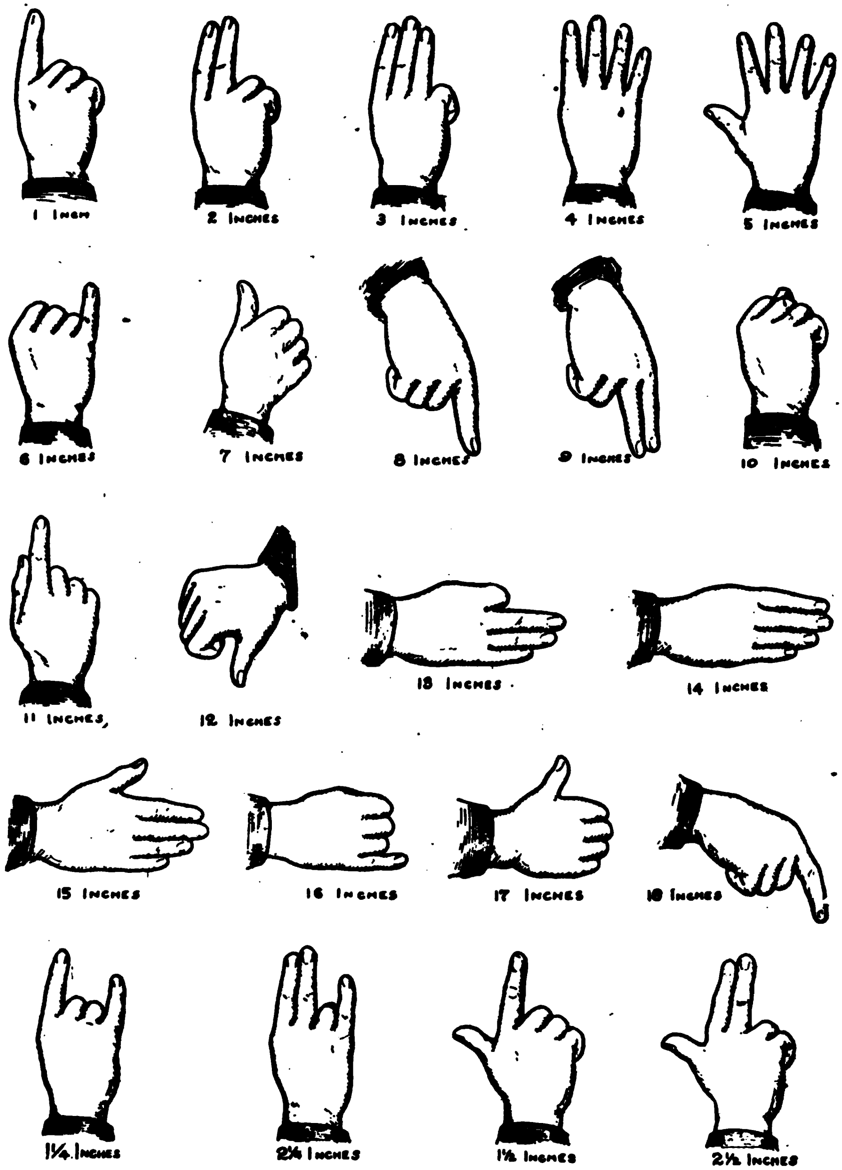


Fig. 16. Sawyers' sign language.

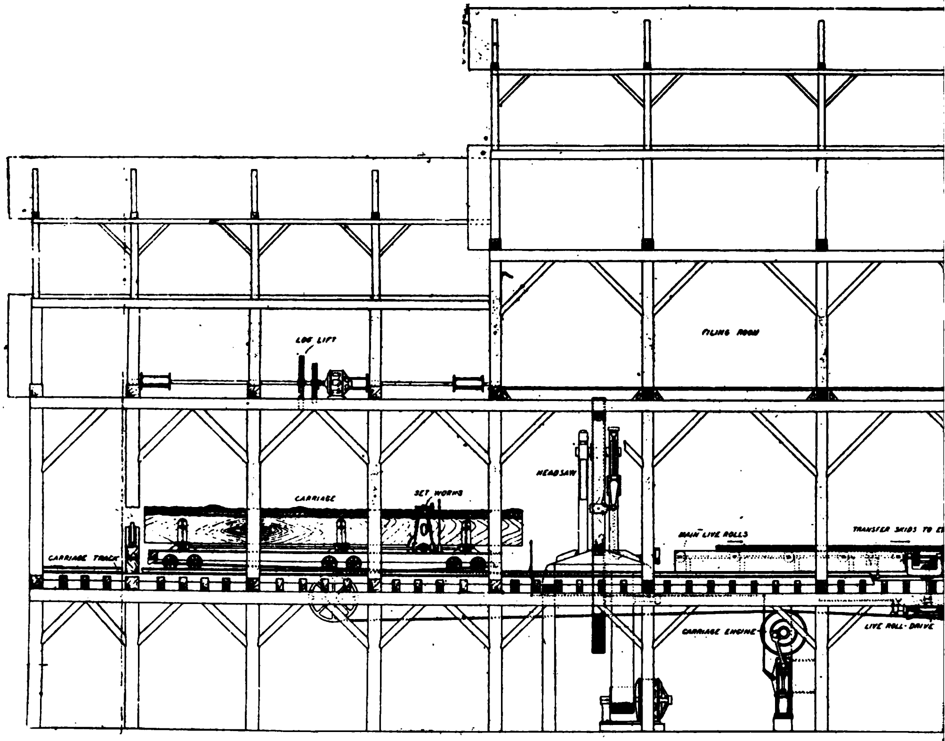


Fig. 5. Side elevation of a si

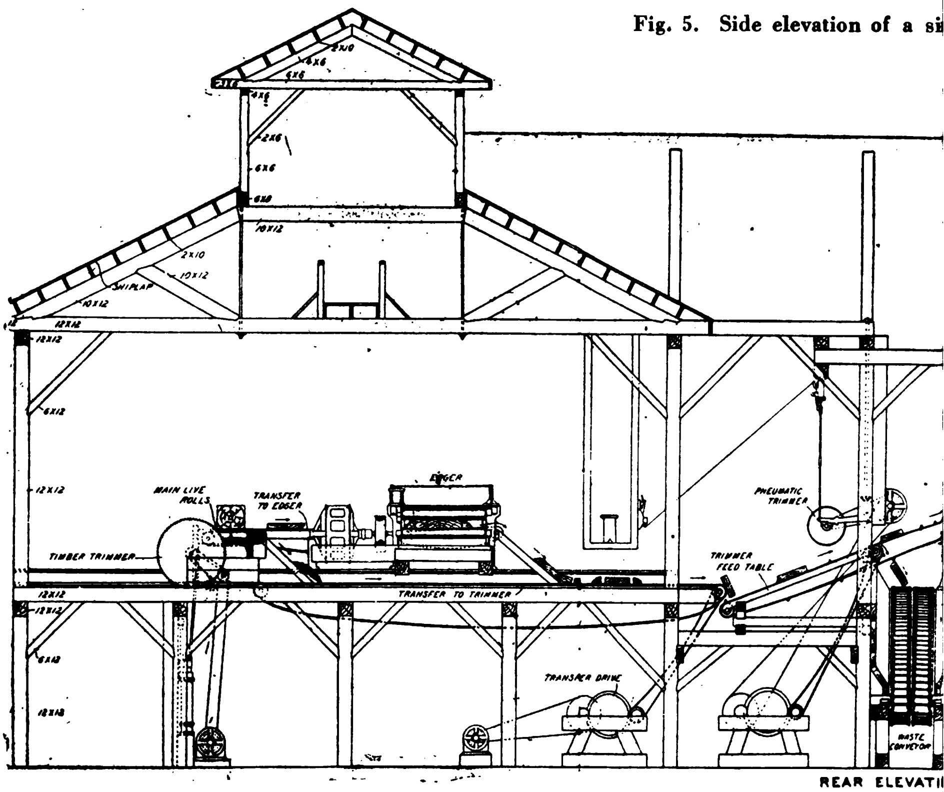
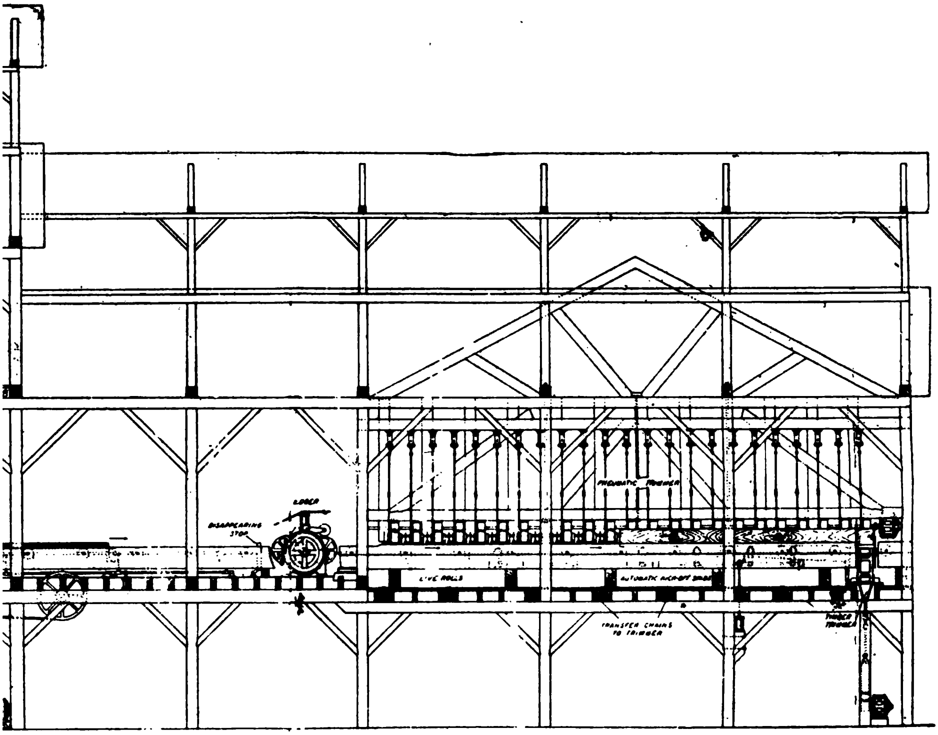
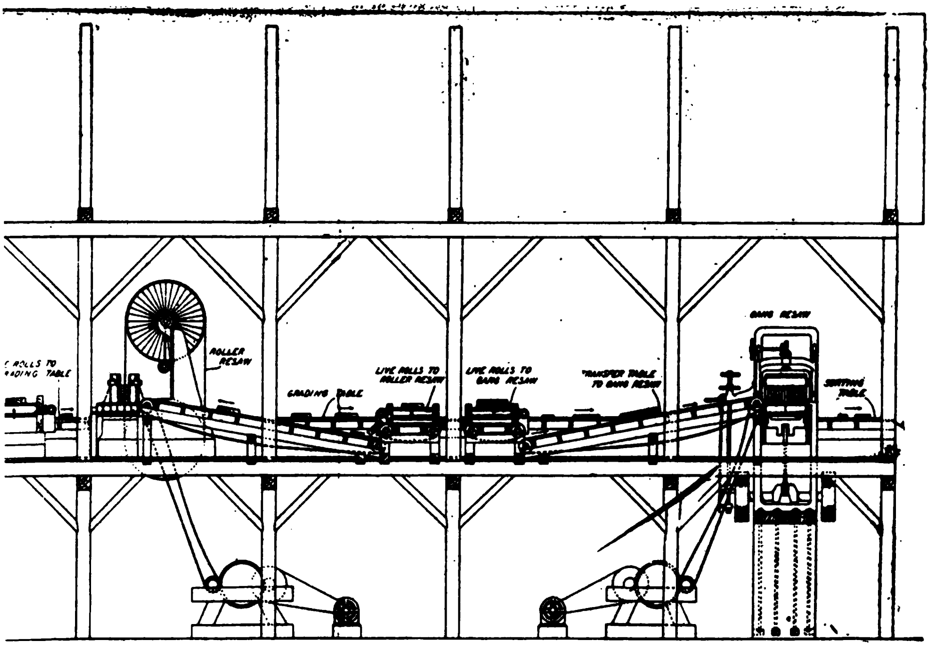


Fig. 6. Rear elevation of a si



ELEVATION

band Douglas Fir sawmill.



band Douglas Fir sawmill.

The same thing pertains to a half, the thumb representing the half. For example, 4½ cannot be given with one motion, as a combination of the four fingers and thumb makes five. It is given, therefore, by first raising the four fingers with the thumb closed, then closing the four fingers and raising thumb.

In giving the sign for an eighth, the sign for eight, index finger down is used. Take 7⅜ as an example; hand closed with thumb up for 7, followed by three fingers up, then index finger down for ⅜.

Instructions to turn the log are given by raising open hand with palm out, then dropping same to side.

The order to set log for cutting off slab is shown by raising closed fist and holding same up until the log has been set at proper place, then dropping fist to side.

In cutting lumber of special thickness, there is an understanding between the sawyer and setter. Each mill has some special signs along these lines, which are local, and which are not of general use.

CANT LOWERING DEVICES

As the heavy fir cants fall from the log upon the main rolls, they are frequently injured by the force of the impact unless the rolls are as wide as they are or wider. Ordinarily, the top edge, which is the one that develops the greater momentum, overhangs the rolls, and the tendency is for the impact to produce a crack in the cant along the line of overhang.

Devices have recently come on the market (Fig. 17) to lower the cants with a pneumatic or steam cylinder in such a way that the shock is absorbed. This not only prevents the cracks mentioned above, but it reduces the wear and tear on the rolls and roll bearings and also saves an enormous amount of strain on the entire front end of the plant. The number of lowering arms in the series depends on the length of the logs cut. They are usually spaced from 8 to 10 feet apart. These devices cost about the same as the log stops used on the deck.

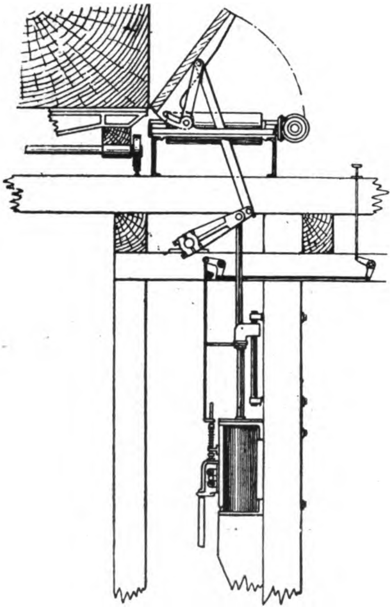


Fig. 17. Cant lowering device.

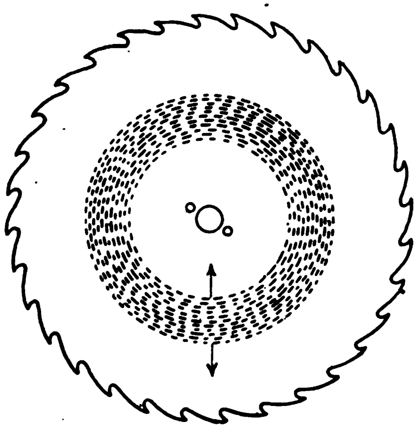


Fig. 18. Tensioning circular saws, area hammered in "opening up" a circular saw. Arrows indicate flow of metal.

EDGERS

TYPES

Sawmill edgers have three functions, all of which have an important bearing on the quantity, quality, and value of the final lumber products.

The primary function is to remove the wane or rounded edges from the cants or flitches coming from the headsaw. The next is to divide the cants into strips of desired board widths, and the third is to separate the clear or valuable portions of the cants from the knotty or low grade parts. All of these objects are accomplished in one operation, and it is this variety of purposes which greatly complicates the process of edging. The operation is separated into two distinct parts: First, placing the cant in position properly to be fed into the machine and arranging the saws for their work; second, feeding the stock through the machine. The first requires mental and the second mechanical efficiency.

The edgers are of single and double types. The double edgers have split feed rolls which permit feeding two "cants" of the same or different thickness into the machine at one time. Some of these double edgers have two edging crews and are operated as two machines. By combining the two machines, added width is obtained for emergency use and the cost of equipment and installation is materially reduced.

Edgers are also classified as to right or left hand, according to the side of the machine upon which the drive is connected.

The cants are fed through the machine (Fig. 19) horizontally over spiked or groove feed rolls 8 to 10 inches in diameter against a series of vertical saws on a common arbor. From above, heavy press rolls operated by double acting steam cylinders force the cant down upon the feed rolls, insuring perfect contact and preventing any "kick back" from the thrust of the saws. Similar rolls in the rear remove the material from the machine. The saws on Pacific Coast edgers are moved by means of short self-locking hand levers directly connected to forked saw guides, each having contact with both sides of one saw. The saw can be slid in either direction by simply moving the lever handle.

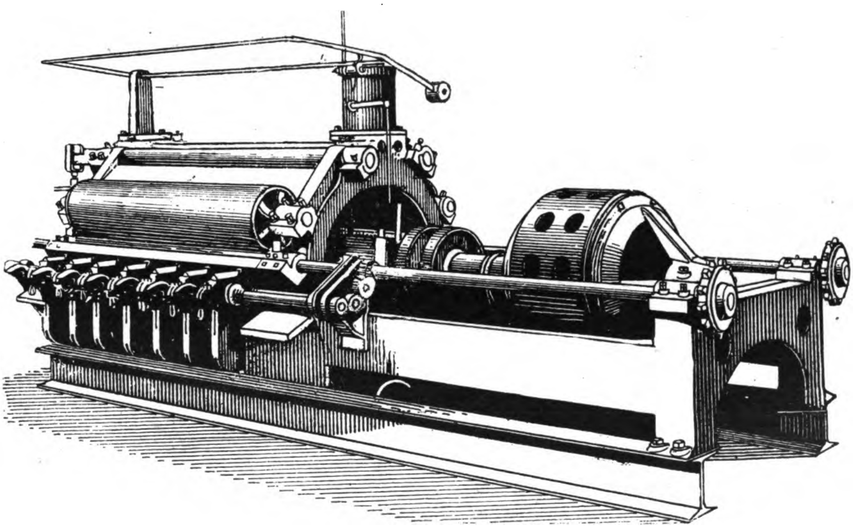


Fig. 19. 7-saw edger with mechanical saw shifting device.

SIZE AND CAPACITY

The common size of edgers is 10 x 72 inches, although in the last two years several 12 inch and 14 inch edgers, designed for taking extra thick cants, have two advantages. The greater advantage is the higher rate of speed with which all thicknesses of stock can be fed through such machines. The other is that thick cants for making V. G. stepping and similar stock do not need to be rehandled on the log carriage to get the proper grain, as is frequently necessary in mills equipped with edgers too small to take cants the thickness of stepping boards.

The size indicates the greatest width of material which can be fed to the machine; about 3 inches for every saw must be subtracted from this to get the widest possible material which can be put out by it, this allowance being for the overall width of the saw collars when they are placed at the sides.

The 10-hour capacity of present 10 inch edgers operated with single crews varies from 75,000 to 150,000 feet, depending upon the thickness and width of cants, while the 12 inch and 14 inch edgers ordinarily cut up to 175,000 feet with single crews, and from 250,000 to 300,000 feet are being put through the machines.

COST

Below is given the cost and weight of edgers.[1]

[1] Data refers to edgers proper. Add 20 per cent to above costs and 15 per cent to above weights to cover pulleys, belts, etc., for feed. These costs do not include rolls and chains in front of or behind the edger, motor costs, or pulleys and belts for shaft driven edgers.

COST AND WEIGHT OF EDGERS (1916)

Size of machine, in.	Weight, lbs.	Cost delivered $	Size of machine, in.	Weight, lbs.	Cost delivered $
10 x 60	11,700	1,350.00	14 x 72	18,000	2,075.00
10 x 72	13,000	1,500.00	10 x 84	14,000	1,750.00
12 x 72	15,000	1,750.00	12 x 84	16,000	1,850.00

SPEED OF FEED

The speeds of feed used on the edgers are not at all uniform even for edgers of the same size operating on the same thickness of stock. This is due to differences in the operating conditions (i. e. the demand for fast speed to take care of the product) and to a large extent to insufficient power to maintain an efficient feed on thick stock (6 to 14 inches) when several saws are in the cut. The maximum feed used is 300 feet per minute. At one plant this speed is maintained for all thicknesses of stock up to 14 inches, even with five or six saws in the cut. This requires an enormous amount of power, but it also increases the capacity of a large edger from the usual production of from 150,000 feet per ten hour day up to more than 300,000 feet for the same period.

The usual practice is to have two or three speeds of feed, so that when thick stock is being cut or when a large number of the edger saws are working the feed can be reduced and the machine operated with less power. The variable speed of feed is obtained either through special drives on pulleys of different sizes, by a disc friction drive, or by a variable speed motor.

The most efficient feed is that which will insure stock being put through the edger faster than it can be made on the headsaw and delivered to the machine.

EDGER SAWS

All edger saws now in common use are of the inserted tooth type, that is, the teeth can be replaced when they become badly worn or broken. The introduction of this type has enormously reduced both the time required in caring for the saws and their cost per thousand feet of lumber produced.

The following table gives number of teeth, size, gauge, kerf, weight, and cost of typical edger saws for machines of different sizes.

COST OF EDGER SAWS (1916)

Size of edger, in.	Number of teeth	Kerf, $\frac{1}{32}$ in.	Gauge	Diameter, in.	Weight, lbs.	Approximate cost F.O.B. Coast terminals, $
8	18	11	7	26	20	25.00
8	20	12	6	28	22	28.00
10	22	12	6	30	26	32.00
10	24	12	6	32	35	35.00
12	26	13	5	34	42	39.00
12	28	13	5	36	48	42.00
14	30	13	5	38	59	46.00

Single edgers 72 inches wide usually have from five to seven saws. Double edgers are equipped with from 8 to 10 saws. From two to five extra saws are required to permit an interchange for filing and tensioning, and to avoid crippling the plant in case of breakage.

The average life of edger saws is about two years, and of the teeth or bits about 2 or 3 weeks.

Edger saw teeth cost 2½ cents each.

POWER FOR EDGERS

The power demanded for edgers depends upon the rate of feed, thickness of cant and number of saws in the cut, and, to a very small extent, on the size of the machine.

Typical daily conditions in Douglas fir mills are as follows:

Starting demand (instantaneous—duration of starting 10-15 sec.) .... 40.0 Kw.
Running light input .... 21.0 Kw.
Average input throughout day .... 27.6 Kw.
Average Kw. Hr. per 1,000 ft. B. M. .... 4.45 Kw. hr.

The average input in the cut varies so much that it is impossible to calculate it with any degree of accuracy.

Maximum input at beginning of cut .... 461 Kw.
Maximum input maintained during cut .... 290 Kw.

Typical 15 minute periods are as follows:

Number of cants in 15 minutes 37
Maximum input in cut to start .... 350 Kw.
Minimum input in cut to start .... 111 Kw.
Idle time .... 10 min.
Working time .... 5 min.

The large amount of idle time is responsible for the low average power demand.

Most edgers, especially those in shaft mills, are equipped with insufficient power to obtain maximum efficiency. This is not so likely to be the case where electric motors are employed. Electric driven edgers have more power because electrical engineers are very careful to supply motors of ample size, because the power cannot be stolen by other machines, and because motors will stand enormous overloads for short periods without stalling.

Edger motors are usually connected directly to the edger arbor, but this is not always possible because in some instances, those of the desired speed cannot be obtained. The size and cost of edger motors are as follows:

SIZE AND COST OF EDGER MOTORS (1916)

Size of edger, in.	Power, h. p.	Speed of Saws, R. p. m.	Weight, lbs.	Approximate Cost delivered, $
8 x 60	150	1,200	3,700	1,200
10 x 72	200-250	1,200	4,700	1,300
12 x 72	250-300	1,200	5,600	1,600
14 x 72	300-400	900	8,200	2,025
		900-950	10,000	2,500

Prices given above are for direct connected motor complete with compensators; no couplings are included.

The following are prices on belted motors of similar ratings complete with base, pulleys, and starting compensators.

COST OF BELTED MOTORS (1916)

Power, h. p.	Speed, R. p. m.	Weight, lbs.	Cost delivered, lbs.
150	900	4,640	1,200
200	600	7,200	1,615
250	600	12,600	2,760
300	450	14,500	3,440
400	450	15,000	4,240

Edger saws, like other circular saws, do better work when not speeded up too fast. High speed tends to make the saws wabble. Where motors of desired speed cannot be obtained for direct connection, the saw speed should not be changed, but provision should be made to obtain the desired speed by pulleys or gears, preferably by the latter.

The edger feed rolls are usually driven by a pulley on the machine arbor, recently they are being run by variable speed reversing back geared motors with speeds of 600, 900, 1,200, and 1,800 R. p. m. The feed drive is independent of the machine drive and requires a 7.5 h. p. motor, depending upon the size of the machine. These motors cost $450 and $475, respectively (1916).

MECHANICAL LINER

A device has recently come on the market for mechanically lining up cants to be edged. It usually does away with the services of a liner-man and in addition greatly assists the edgerman in quickly getting the cants into position. The equipment consists of a series of chain transfer skids placed between the rolls in front of the edger and raised and lowered independently by steam or air cylinders. One set of the skid chains moves in one direction and the other in the reverse direction.

By this means it is possible to align the cant by simply raising whichever of the skids under one end is traveling in the right direction, carrying the end of the cant to the desired spot, and then lowering the skid, the other end being allowed to rest on the rolls the meanwhile.

These liners with four skids and drive cost about $900 and weigh about 13,000 pounds. Five skid liners cost about $1,100 and weigh 16,000 pounds. A ten horse power motor is required for this device.

LOCATION OF EDGER IN MILL

The location of the edger is an important element of sawmill design, since it affects the size of the mill frame as well as the efficiency of the plant.

The edger is placed in a line parallel to the line of travel on the rolls and usually at a distance from the headsaw slightly greater than the length of the longest logs to be cut in considerable quantities. Provision may be made for handling unusually long pieces by cutting them in two with a jump saw placed in the rolls leading from the headsaw. Such practice retards the headsaw and is usually followed only in getting out special orders. On the other hand, too great a distance between these machines unnecessarily increases the length of the mill and correspondingly the cost of the mill building and certain equipment, such as live rolls and shafting.

The edger is placed far enough away from the main line of rolls to allow ample storage of cants, so that temporary delays at the edger will not prevent continuous operation of the headsaw, but not so far away as to make the mill building unnecessarily wide.

OPERATIVES AND THEIR DUTIES

The edging operation in most Douglas fir mills requires the services of three men, one highly skilled, and the other two practically unskilled laborers. The skilled operator, who is called the edgerman, stands directly in front of the machine and regulates the width of the pieces by increasing or

decreasing the horizontal distance between the various vertical saws until their cutting lines will divide the cant properly as it passes through the machine. With the assistance of one of the unskilled laborers called a linerman, the edgerman must also swing the cants into a position paralleling the edger saw lines, so that the boards will run true with the grain of the wood. This is to avoid waste and to prevent diagonal grain, which is a defect.

Since the cants come to the edger in quick succession, the work must be accomplished with great briskness. The edgerman's duties require both rapid and keen judgment because of the speed at which he works and the effect the edging operation has on the amount and quality of the product obtained from the logs. While he is placing the cant in position to be edged, he must hastily calculate what saw cuts will yield the most desirable product from the standpoint first, of quality, and second, the demand for various sizes. In addition, he must make his outer cuts the full width of the merchantable wood, or there will be unnecessary waste.

The other unskilled laborer connected with edging is called the off bearer. His duty is to separate the waste strips from the good strips as they leave the machine by pushing the waste strips off the rolls which carry the good strips to the lumber trimmer Some mills do away with this off bearer by putting the waste strips through the trimmer with the good lumber instead of sending it to a slasher as is usually the custom. This practice has the advantage of allowing the trimmerman to decide whether a piece is worth saving.

Mills cutting over 150,000 feet per day usually have two edging crews. They work either on one large double machine or at separate machines.

SLASHERS

Slashers (Fig. 20) are used to reduce the waste pieces from the headsaw and edger to 4-foot lengths, a size suitable for lath and fuel.

In Douglas fir mills cutting 130,000 feet or less, it is often more efficient to accomplish this on the trimmers, so the mills are designed without slashers (Fig. 5). In larger mills such practice may overburden the trimmer because of the large number of additional (25-30 per cent more) pieces to be handled. In addition to disposing of the edger off bearer, such practice reduces the cost of the mill about $3,000 (exclusive of the slashers) and gives a skilled operator final disposition of each piece. This last feature is very important, since the general tendency among off bearers is to waste too much material.

The slasher may be placed on either side of the mill to suit the layout for getting at fuel wood and delivering refuse to the burner. Slashers are usually made to accommodate pieces about the same length as the trimmer.

The saws, which are all hung on the same arbor, are spaced 4 feet apart, except at some of the export mills where lath 4½ feet long is made for the off shore trade. A 40 foot slasher is usually constructed with only 9 saws, and a 44 foot one with 10 saws, the extreme end saws being omitted. The saw collars are large, often 12 inches in diameter, to prevent the saw from cracking.

Spiked chains are ordinarily used on both the transfer table and the feed table. Those on the transfer table are 4 feet apart. On the feed table there is one chain on either side of each saw, one at the extreme ends, and one midway between each saw to prevent pieces from remaining on the table after the cut. The feed tables are from 10-12 feet long. The transfer tables are of sufficient length to receive material from both the main and edger rolls.

Spring set cross cut saws are used on the slasher. They are usually one or two gauges heavier than trimmer saws of the same size and are operated at approximately 9,000 feet rim speed per minute. It is the general practice to file and hammer one saw a day, so that each saw is filed every eight or ten days. The process of filing and setting is the same as for the trimmer saws.

Most mills have a man on the slasher to straighten pieces which get askew or untangle material when edging pieces fall across slabs already on the table. Many mills operate without such a man, relying on other members of the crew to look out for tangles.

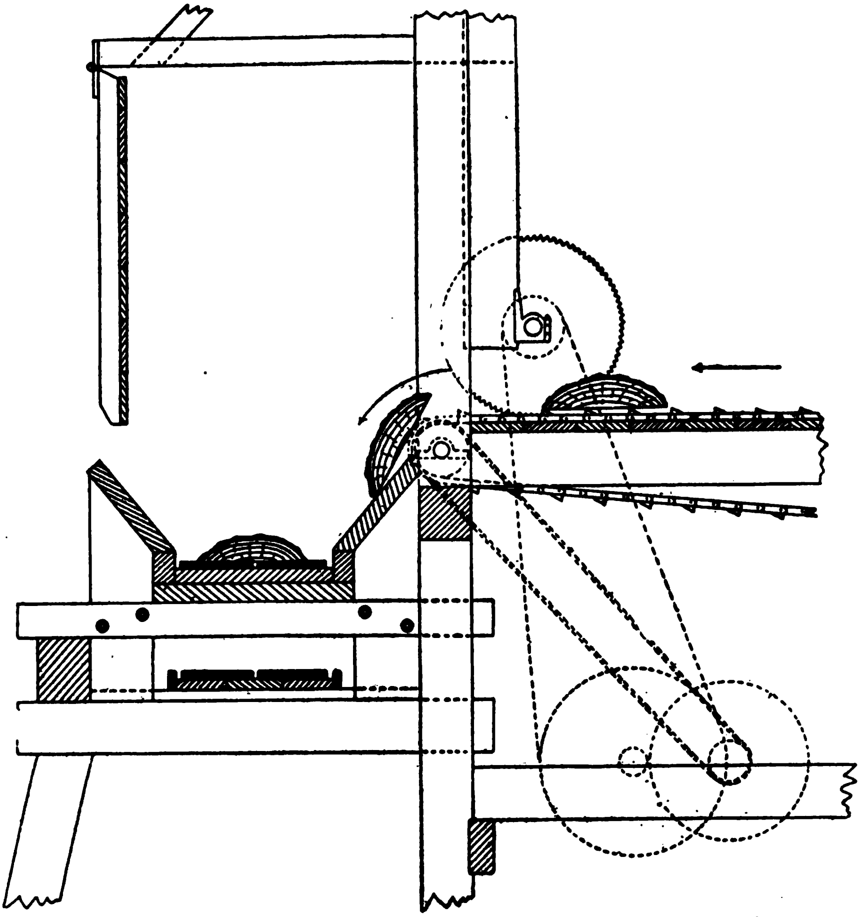


Fig. 20. Cross section of slasher for cutting slabs to 4-foot lengths.

COST

Following is given the size, and weight of representative slasher saws. The 42 inch saw is most common.

COST OF SLASHER SAWS (1916)

Diameter, in.	Gauge	Weight, lbs.	Cost F.O.B. coast, $
36	8	42	18.00
38	8	51	19.25
40	7	65	23.75
42	7	83	27.25

The cost (1916) of slashers, exclusive of saws and motors, but including feed table and feed works, is approximately $1,000. Slashers weigh from 7,000 to 10,000 pounds, according to length.

POWER FOR SLASHERS

Slasher motors vary in size from 25 to 50 h. p., according to the number of saws. A direct conected 900 R. p. m. motor is ordinarily used. This motor also drives the feed table by means of a pulley on the saw arbor

A 25 horse power motor weighs 1,320 pounds and costs $380; one of 30 horse power weighs 1,670 pounds and costs $480; and the 50 horse power motor weighs 2,300 pounds and costs $550, (1916). Motors are alternating current squirrel cage induction machines complete with pulleys, bases, and starting compensators.

TRIMMERS

TYPES

The object of the trimming operation is threefold; to square up the ends of the prospective boards, making a true right angle with the sides, top, and bottom; to reduce the board to desired standard lengths (multiples of two feet); to remove defects which impair the grade of the board and to separate high grade portions from low grade portions in the same piece.

There are two distinct types of trimmers in use in Douglas fir mills, al though one of them is restricted to small mills (under 60,000 feet). The small mill variety is the single swing cut-off saw. The saws are usually quite large, to trim fair-sized timbers and also to permit rapid cutting. The other is the so-called "automatic" trimmer (Fig. 6) consisting of a series of from 18 to 22 independent saws two feet apart and controlled by pneumatic cylinders through a key board of levers from a point above the trimmer feed table.

The boards are fed against the saws by a series of pegged chains. one passing to either side of each saw. The pegs are arranged on the chains at uniform intervals (from 3 to 4 feet) and in rows paralled to the arbor, so that the boards will be presented to the saws at right angles.

The air compressors used in the supply of air to the cylinders for manipulating the trimmer saws vary considerably as to design and capacity. When air is used at the trimmer alone (and not for cleaning purposes, as with air hose lines) the locomotive type compressor is often used. Larger compressors are built in horizontal stationary units which occupy considerable floor space and are direct acting steam applications with duplex or compound air and steam cylinders. The electric motor driven compressor is rare. The size of locomotive compressor commonly employed for large trimmers is 11 x 11 x 12 inches.

It costs about $500 installed (1916), including a 30 x 72 inch receiver (storage tank).

The helper who works constantly in front of the trimmer saws is in a precarious position, for should he fall upon the feed chains he would be carried quickly against the saws. A few of the modern mills have installed iron pipe fences or railings across the front of the trimmer to protect the workman and to relieve him of the nervous strain caused by his constant danger.

SIZE AND CAPACITY

The size of a trimmer is gauged by its length or the distance between the outer saws. In the fir region trimmers thus vary from 32 to 44 feet; the representative size is 40 feet. The width or distance carried varies from 6 to 10 feet. These give actual working distances of 3 and 7 feet, respectively, before the saw comes in contact with the board. The greater dis-

tance is more efficient because it gives the trimmerman a better opportunity to view the board and thus greater time to adjust or change his saws after the board is on the table.

Forty foot trimmers equipped with fast feed and pneumatic saw control have a capacity up to 175,000 feet per 10 hour day on average material, or 300,000 feet on thick stock. Where the majority of the pieces are small or short, this output cannot be reached.

COST

The weight and cost of trimmers vary somewhat with the make, but the following are representative figures for the fir region for 40 foot and 44 foot machines. The cost includes cylinders, pulleys, chains, troughs, drive, etc.

COST AND WEIGHT OF TRIMMERS (1916)

Size	Number of saws	Weight, lbs.	Cost delivered, $
40-foot	21	25,000	2,000.00
44-foot	23	27,500	2,200.00

The cost of installation is about $200.

SPEED OF FEED

The rate at which the feed chains are operated varies at different plants from 40 feet to 100 feet per minute, most often the latter Some machines are equipped with a variable friction drive, which is desirable where considerable very thick stock, from 8 to 12 inches, is sent over the trimmer table, although two speeds would probably work satisfactorily and relieve the trimmerman of constantly regulating the rate of feed.

The frequency with which the rows of pegs advance the boards to the saws obviously depends upon both the distance between them and the rate of feed. With 4 feet as the representative distance between pegs, their frequency is 10 boards per minute on a 40 foot feed and 25 per minute on a 100 foot feed. Though the frequency of 25 per minute, or approximately 3½ seconds apart, is faster than the trimmerman can work to advantage, it permits the boards to follow one another rapidly onto the feed table.

SPEED OF SAWS

Trimmer saws are operated at a rim speed of from 8,000 to 11,000 feet per minute, the speed ordinarily used being 9,000 feet. A saw speed of more than 9,000 feet can do no harm, because the trimmer has such a short cutting distance that imperfections in sawing are of minor importance.

SIZE AND COST OF SAWS

Saws vary in diameter from 28 to 40 inches. Most of them are 30 inches, although in a few years, with the increased use of 12 inch and 14 inch edgers, many larger saws will probably be used.

Trimmer saws are spring set for cross cut work, and therefore have a small tooth and gullet. The space between the tooth points varies from 1⅛ to 1⅝ inches, but ordinarily is 1½ inches. Second hand shingle saws are often used for this work.

Following are the size and cost of trimmer saws:

SIZE AND COST OF TRIMMER SAWS (1916)

Diameter, in.	Gauge	Kerf, in.	Cost, $	Weight, lbs.
28	10	.27	11.00	21
30	10	.27	11.50	24.5
32	10	.27	13.25	27
34	9	.29	14.00	33
36	9	.29	17.00	40
38	9	.29	19.25	55
40	9	.29	22.50	75

Thirty inch trimmer saws will not cut stock thicker than 10 inches.

When properly filed, trimmer saws will last several years unless they are broken by accident. Three saws a year will keep the average plant in operation. Trimmer saws are hammered and sharpened in proportion to their use. The following chart shows the frequency of such work in a Douglas fir mill.

Position of saw (distance from head end), feet	Changed in days	Position of saw (distance from head end), feet	Changed in days
0	1	22	5
2	7	24	5
4	3	26	5
6	6	28	5
8	3	30	6
10	5	32	6
12	3	34	6
14	4	36	6
16	3	38	6
18	4	40	7
20	3	42	7

The above tabulation provides for the care of saws where slabs and edgings are cut into 4 foot lengths on the trimmer. Where this is not done, the saws are not changed so often.

POWER FOR TRIMMERS

The load or power demand for a trimmer is exceedingly variable because of the intermittent character of the operation and the variation in the size of the stock and the number of saws. For this reason the average daily demand is not much in excess of the demand when the machine is running light.

A 50 h. p. motor is usually employed, and may or may not be connected direct to the arbor which drives the series of pulleys used for the individual saws. The same motor also drives the feed chains of the machine, and sometimes the transfer chains which bring the lumber to the trimmer.

The following power data are representative:

Input running light	16 Kw.
Average input for the day	29 Kw.
Maximum—instantaneous	105 Kw.
Maximum—sustained (5 seconds)	70 Kw
Kw. Hrs. input per thousand feet	3.95 Kw. Hr.
Input for various sizes of stock:	
3 saws—2″ x 16″	44 Kw.
4 saws—2″ x 12″	52 Kw.
9 saws—2″ x 12″	95 Kw.
3 saws—2″ x 14″	48 Kw.
1—3 saws in 1 x 4, 2 x 4, 1 x 8	27 Max. 18 Min.

A 720-900 R. p. m., 50 h. p. motor, suitable for trimmer operation, costs $600-$700 (1916) and weighs 2,420-2,850 pounds complete with flexible coupling and starting compensator.

OPERATIVES AND THEIR DUTIES

The trimmerman sits in a "cage" above the trimmer table with full vision of the boards to be trimmed and the trimming machine. Like that of the edgerman, his work requires quick judgment in deciding how to increase the net return to the mill owner. The loss in volume by trimming must be rapidly and constantly weighed against the gain in value of the remaining piece. In addition, each cut must be governed by the lengths desired, and the trimmerman must therefore know the actual and relative lumber values for each grade and size.

When a piece divides itself naturally into two distinct grades, the operation is quite simple. But when several defects are scattered through a

high grade piece, the task of balancing waste and increased value is much harder. To do this quickly requires a great deal of practice. Many trimmermen have a good idea of how their work should be done, but the speed and strain under which they work prevent the best results. Others give little thought to relative values, but trim out the defects as they appear and assume that they have accomplished their work correctly.

The trimmerman is usually assisted in his work by two helpers, though in some of the more modern plants properly designed he has but one helper. When two men are used they slide or lift the pieces from the transfer chains to the feed table, and as it is conveyed toward the saws, the trimmerman lowers the proper saw or saws to give the desired board length or lengths. Where but one man is used, the transfer chains are extended, so that they overhang the feed table at a height of about 12 inches as shown in Fig. 6. The movements of both the transfer chains and the feed chains are controlled by the trimmerman. As each board drops from the transfer upon the feed table, it turns in falling so that the trimmerman has an opportunity to see both sides of the piece. The duty of the helper in this case is to straighten up pieces on the transfer and pull them toward or push them from the zero saw on the feed table when they are not in the correct longitudinal position to be trimmed properly.

TIMBER TRIMMERS

Equipment for trimming timbers (Fig. 21) in Douglas fir mills consists of a single circular saw which is raised or lowered by means of steam or air cylinders or counterweights. There are two general styles, namely, those suspended above the rolls and those below the rolls. The latter is the prevailing type.

These timber saws are usually located on the main live rolls close to the rear end of the mill where the work can be conducted without interfering with other operations. One type of saw raises in a straight line and another in an arc. The latter type, shown in Fig. 21 is said to be the better. One man can operate one of these machines and look after other work when no timbers are being cut.

Disappearing timber trimmers cost complete, exclusive of saw and motor, from $200 to $225 (1916) and weigh from 2,000 to 2,500 pounds, depending upon the style. The installation cost is from $30 to $40.

The saws vary in size with the size of the timbers to be trimmed. The 48 inches and 50 inch saws are most common (1916).

COST OF SAWS FOR DISAPPEARING TIMBER TRIMMERS (1916)

Diameter, in.	Gauge	Weight, lbs.	Cost F.O.B. coast, $
48	8	136	41.25
50	8	148	46.75
52	7	160	52.25
54	7	170	57.75
56	7	180	66.00
58	7	195	74.25
60	6	210	82.50

Like the trimmer saws, these saws are spring set for cross cut work. Normally they require filing about once a week. One extra saw should be available in case of breakage.

The saws are operated at a speed of from 9,000 to 10,000 feet per minute.

The power demand for timber trimming is extremely variable; the actual consumption is low though the demand in the cut is often considerable. Fortunately, the demand in the cut can be regulated by the operator, so that a small motor of from 5 to 7.5 h. p. can be used, even though the maximum demand would require a much larger motor if the saw were forced rapidly through the cut. The fly wheel affect of the heavy saw

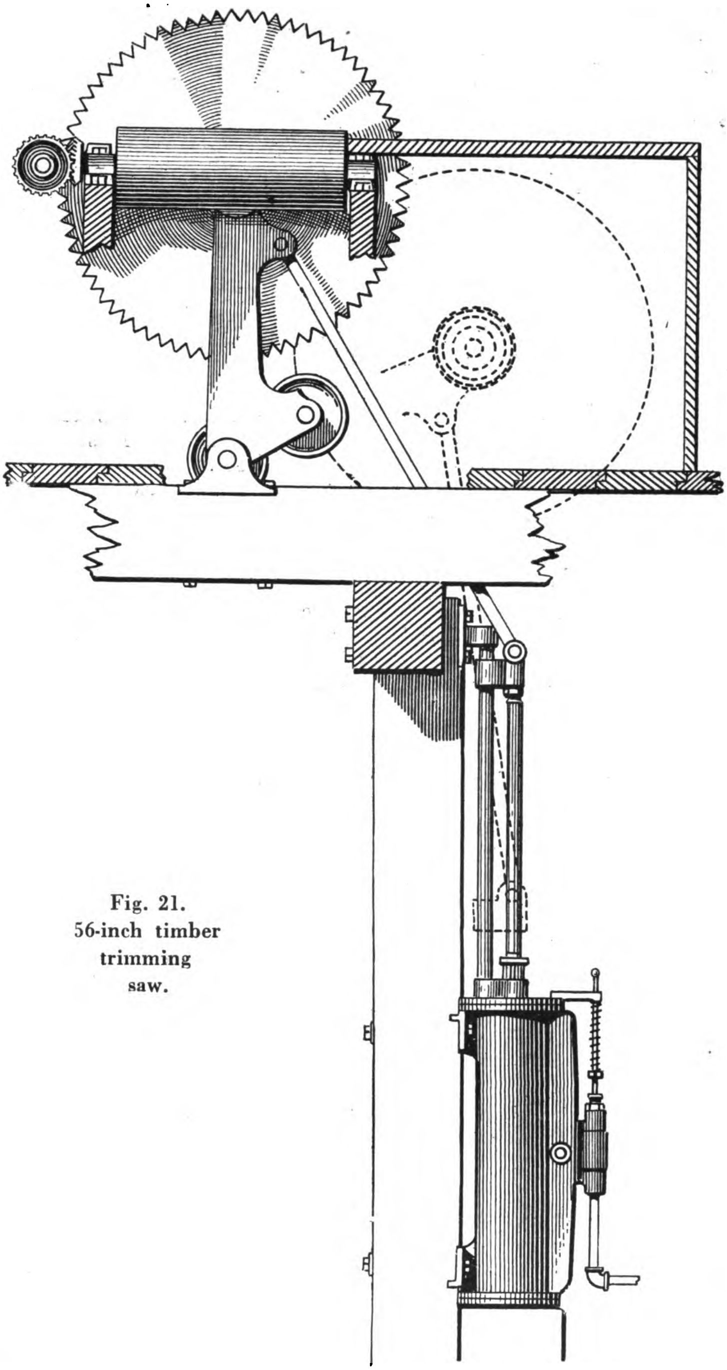


Fig. 21.
56-inch timber
trimming
saw.

is of great assistance, since the duration of cutting is very short and the saw has opportunity to pick up between operations.

The following data obtained on a 60 inch timber saw are illustrative:

Input running light	3.5 h. p.
Starting—sustained	14 h. p.
12 x 12—slow	8.5 h. p.
12 x 12—fast	11 h. p.
16 x 6—slow	11 h. p.
Average load in cut	8 h. p.

The motors for this class of work cost from $125 to $215 (1916), depending upon the size and speed.

SAWMILL ROLLS AND CONVEYORS

LIVE ROLLS

Live rolls are used for conveying cants and boards, lengthwise, to and from the various machines. The size of the rolls and their spacing depends upon the size and weight of the pieces to be moved. The usual spacing is five feet, although in some mills it is four feet. With a 4-foot spacing there is less chance of short pieces being caught between the rolls, but the expense of installation is greater.

There are several types of rolls on the market. One has three bearings and the gears are encased in an oil-filled jacket to reduce the wear. This is being largely used in the better built mills, and though its cost is greater, it probably gives better satisfaction in the long run than the common rolls with two bearings and no oil filled gear case.

Where the boards or cants are to travel at a high rate (500 feet or over) the rolls are sometimes driven by chain and sprocket instead of by bevel gears.

The movement or control of the rolls is usually left to one of the operatives nearest them, although in large mills several series of rolls and transfers are frequently operated by a man who does nothing else. The usual rim speeds of rolls are from 150 to 300 feet per minute, although faster speeds up to 550 feet per minute are used to take lumber away from fast feed headsaws. High rim speed greatly increases both the wear and power required.

Owing to the variety of rolls and boxes on the market, it is impossible to give accurate costs and weights of such items. The following, however, are prices of cast chilled rolls with ordinary gears and three-way gear boxes in use in the better constructed mills. Cheaper equipment may be purchased.

CAST ROLLS FOR GENERAL WORK (1916)

Size, in.	Weight, lbs.	Shaft, in.	Delivered cost—each, $
10 x 30	475	$2\frac{3}{16}$	30.00
10 x 36	565	$2\frac{7}{16}$	35.00
10 x 42	610	$2\frac{7}{16}$	38.00
12 x 36	700	$2\frac{7}{16}$	44.00
12 x 42	840	$2\frac{11}{16}$	55.00
12 x 48	925	$2\frac{11}{16}$	60.00
14 x 42	1,025	$3\frac{7}{16}$	65.00
14 x 48	1,125	$3\frac{7}{16}$	70.00

PIPE ROLLS (BEHIND EDGERS) (1916)

Size, in.	Weight, lbs.	Shaft, in.	Delivered cost—each, $
8 x 60	500	$2\frac{3}{16}$	30.00
8 x 72	550	$2\frac{3}{16}$	35.00
10 x 60	700	$2\frac{7}{16}$	40.00
10 x 72	775	$2\frac{7}{16}$	45.00
10 x 84	850	$2\frac{7}{16}$	50.00

The above weights and costs include 5 feet of standard shafting used for each size and 3-way oil case boxes for each roll. They do not include any drives, trusses, or skids.

The total installed cost of the wooden portion of live roll frames is from 70 to 75 cents per linear foot. The wooden frames require from 25 to 30 board feet of select common lumber per linear foot of rolls.

A typical live roll drive designed for extra heavy work is shown in Fig. 22. It can be used with either shaft or motor drive. For light work the multiple gear is eliminated. These drives are made in two or three sizes to meet different working demands. For comparatively light work they cost $125 and weigh about 1,650 pounds; for heavy work they cost $150 and weigh about 2,000 pounds (1916). These figures include boxes, pulleys, friction gears, and other parts except belts.

The following data give a general idea of the power required to drive live rolls as determined from tests made on different numbers of rolls of various sizes operated at different speeds. They indicate that the speed and type of the rolls are a greater factor than the size and number. The additional load when cants or boards are carried is usually negligible.

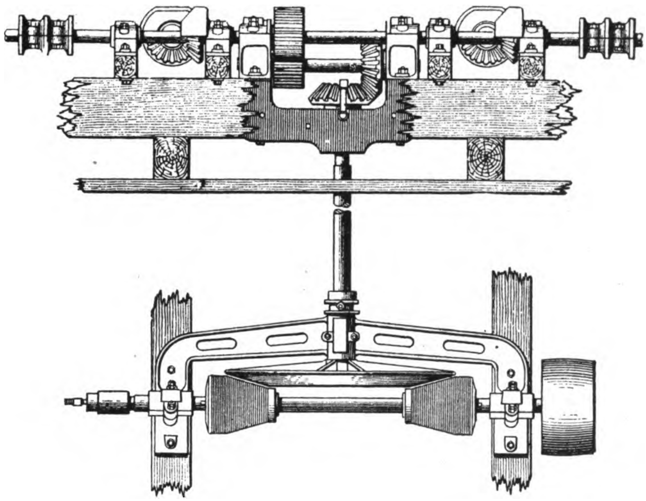


Fig. 22. Double geared live roll drive for heavy work.

LIVE ROLL POWER REQUIREMENTS

Number of rolls	Size of rolls, in.	Kind of rolls	Rim speed, ft. per min.	Power used, Kw.
10	10 x 80	Pipe	300	1.47
21	8 x 36	Pipe	237	2.4
5	8 x 36	Cast	200	1.2
5	10 x 36	Pipe	155	1.2
10	10 x 48	Pipe	150	1.3
11	10 x 48	Pipe	150	1.3
13	12 x 48	Cast	283	1.55
13	12 x 48	Cast	380	4.6

The above are for the rolls only and do not include friction loss of transmission and motor losses.

The usual size of motors for this work is from 7.5 to 15 h. p.

COST OF LIVE ROLL MOTORS (1916)

Horse power, h. p.	Weight, lbs.	Cost delivered, $
5	340	125.00
7.5	750	245.00
10	1,120	335.00
15	1,520	405.00

Motors complete with pulleys, base, compensators. On a 5 h. p. motor no starting compensator is required; price includes starting switch.

KICK-OFF SKIDS

Kick-off skids, Fig. 23, are used to slide the cants or boards from the rolls at right angles to the direction the stock is moving. This may be done automatically by means of tripping devices, as in the sketch, or by a lever or electric button operated by the nearest operative or a man whose time is devoted to operating live rolls and transfers.

These skids are made in various sizes for use with rolls of different diameters and widths. They come complete with chains and sprockets. The costs given below include the skids, boxes, and the usual amount of shafting. Steam or air cylinders for operating an ordinary series of these skids cost about $50.00.

COST OF KICK-OFF SKIDS (1916)

Size of rolls, in.	Weight, lbs.	Approximate cost of each skid, $
10 x 36	525	50.00
10 x 42	550	52.00
12 x 36	575	55.00
12 x 42	625	60.00
12 x 48	650	65.00

An electric device has recently been perfected which opens and closes the valves on such cylinders, enabling them to be operated by means of a button from any part of the mill.

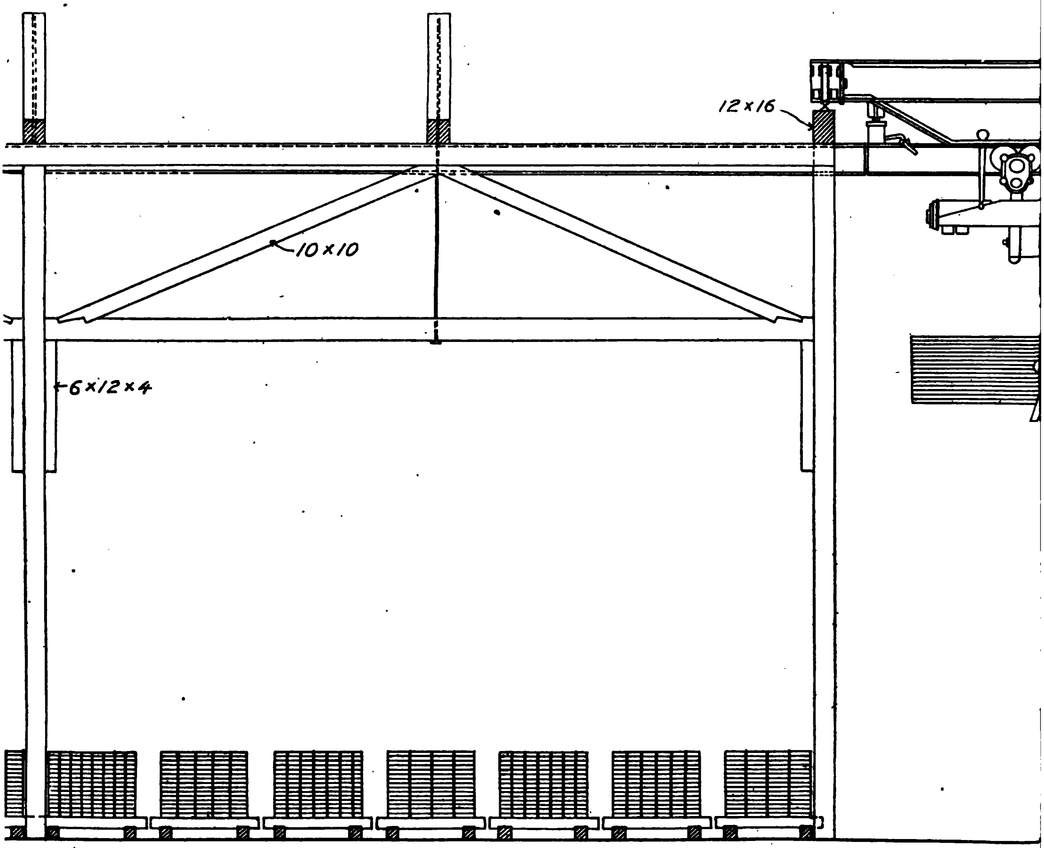


Fig. 29. Side elevation of sorting ta

As is shown in the sketch, the skid chains are driven by means of sprockets on the live roll shaft, so that no provision for drive is necessary, except employment of a little larger motor on the live rolls.

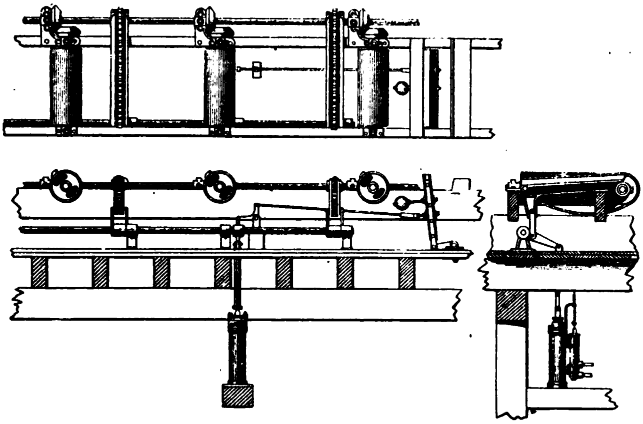
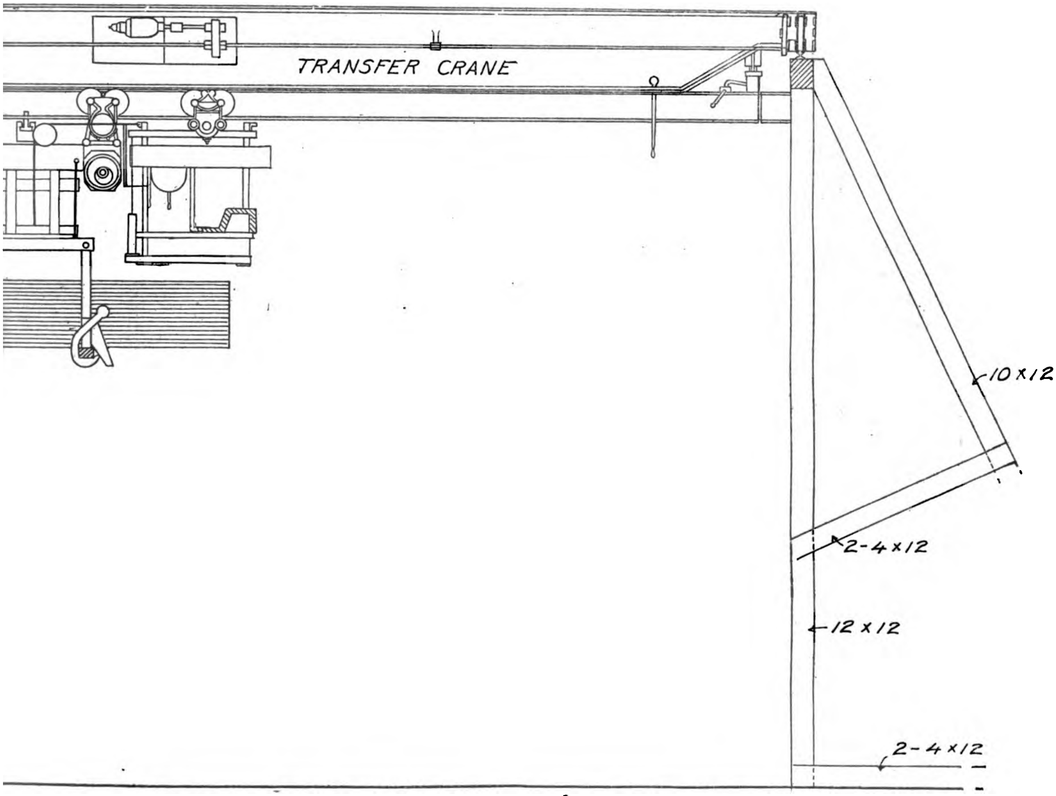


Fig. 23. Top, side and end elevations of a series of automatic kick-off skids.



and monorail, showing transfer crane.

DEAD ROLLS

Dead rolls are used at various places about the plant where driven rolls are too costly or are undesirable from an operating standpoint. They are employed in front of edgers, resaws, gang saws, and the like, and are also used for distributing timbers along the timber storage skids. The material is usually pushed by hand or pulled with a picaroon.

SIZE AND COST OF DEAD ROLLS (1916)

Size, in.	Weight, lbs.	Size of shaft, in.	Cost delivered, $
10 x 24	218	$1\frac{15}{16}$	14.25
10 x 30	245	$1\frac{15}{16}$	15.50
10 x 36	272	$1\frac{15}{16}$	17.00
10 x 72	650	$1\frac{15}{16}$	40.00
8 x 24	154	$1\frac{15}{16}$	11.50
8 x 30	176	$1\frac{15}{16}$	12.50
8 x 36	198	$1\frac{15}{16}$	13.50
8 x 72	475	$1\frac{15}{16}$	30.00
6 x 24	115	$1\frac{7}{16}$	8.50
6 x 30	125	$1\frac{7}{16}$	9.00
6 x 36	148	$1\frac{7}{16}$	9.50
6 x 72	350	$1\frac{7}{16}$	25.00

The above costs and weights include 2 boxes for each roll.

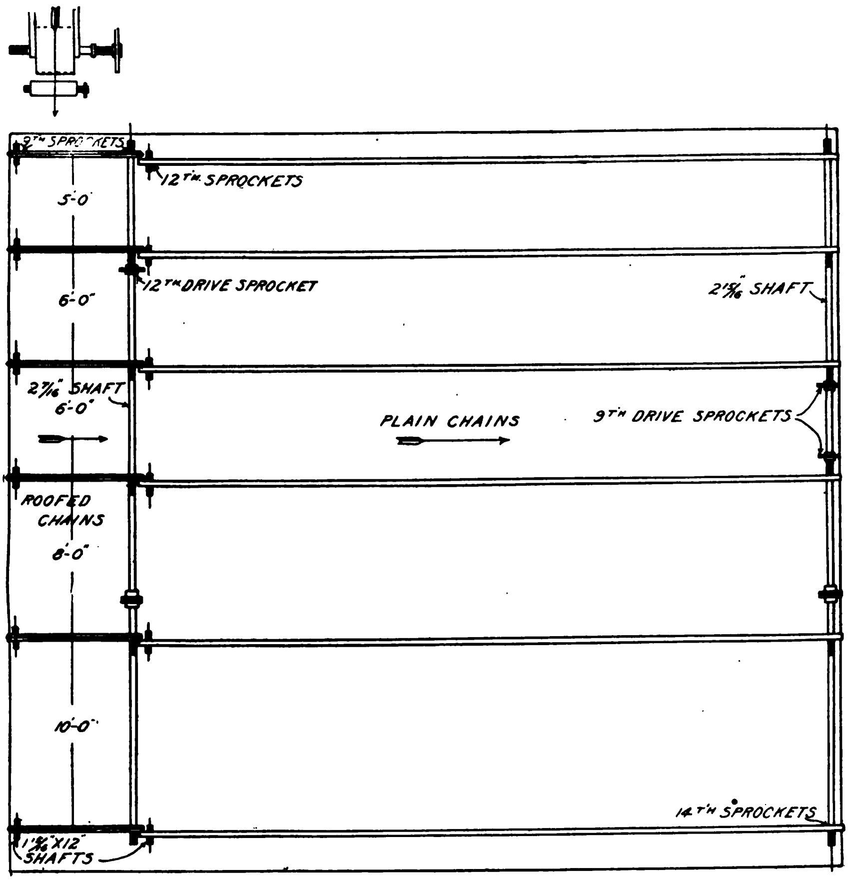


Fig. 24. Typical lumber transfer and storage table.

TRANSFER TABLES

Transfer tables or chains are used to convey boards and cants sideways from one machine to another. They also serve as storage places for material waiting its turn to be fed through machine. They should be as long (direction of movement) as space and expense will permit, in order to insure plenty of room for the accumulation of stock and to prevent any part of the mill clogging when machines are stopped temporarily.

A typical transfer layout is shown in Fig. 24; the side elevations are shown in the general mill sketches. This one is designed to accumulate lumber for and convey it to a resaw. The spacing and number of chains depends upon the lengths of stock to be handled. The pieces are deposited endwise either from live rolls or from belt conveyors upon the short chains and then upon the long chains. The short chains are of the roofed type (Fig. 25) to prevent the ends of the boards from catching on them, and they run continuously; while the long chains are plain (Fig. 26) and are moved at the will of the operative feeding the resaw. Each of the two kinds of chains is made in a variety of sizes as shown in the table following.

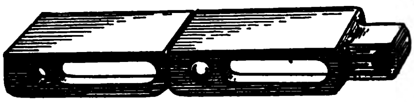


Fig. 25. Roofed transfer chain.

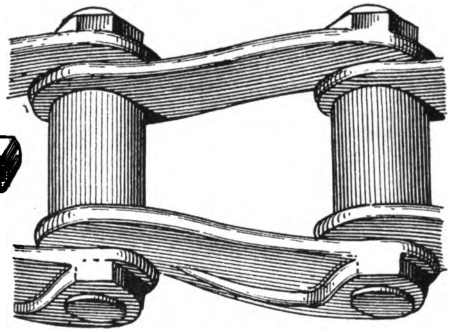


Fig. 26. Plain transfer chain.

The plain chain most used in Douglas fir mills is No. 2; and the roofed chain No. 4. The others are used for light or heavy work as the case may be. Chain No. 3 is used mostly for driving purposes. The cost of these chains varies with the price of metal, but the figures given in the table may be considered as representative.

COST OF CHAINS (1916)

		Dimensions			Approximate weight	Approximate cost
Size	Type	Width, in.	Height, in.	Pitch, in.	per foot, lbs.	per foot, $
1	Plain	2⅞	1	2.06		0.20
2	Plain	3⅛	1⅛	2.06	4.2	.30
3	Plain	4	1⅜	4.0	6.9	.50
4	Roofed	3	1 11/16 [1]	4.0	4.8	.45
5	Roofed	3¾	2¼ [1]	4.0	5.2	.50

[1] Height at center.

The cost of transfer tables varies to such an extent that it is not feasible to present the cost figures for completed tables of different sizes.

The following figures for the essential metal parts can be combined, however, to estimate, with reasonable accuracy, the cost of any given table, where the number of chains and their length is known.

COST OF PARTS OF TRANSFER TABLES (1916)

Part	Heavy (large) Weight, lbs.	Heavy (large) Cost, $	Medium Weight, lbs.	Medium Cost, $	Light (small) Weight, lbs.	Light (small) Cost, $
1. Front and rear sprockets, boxes, and bolts.........	165	15.00	160	13.00	150	10.00
2. Front shaft per foot.....	23	.80	20	.70	15	.50
3. Tail shafts each.........	10	.60	10	.60	10	.60
4. Plain chains per foot....	6.9	.50	4.2	.30	3	.20
5. Roofed chains per foot...	...	....	5.2	.50	4.8	.45

The wooden portions of the tables are not uniform in design and cost, but they usually contain about 5 board feet to each square foot of table and cost from 10 to 12 cents per square foot installed.

The size and cost of drives for transfer chains varies with the size of pulleys, gears, etc., to such an extent that it is difficult to give more than very general figures for such equipment. Below is given the total cost of pulleys, gears, frictions, axes, collars, shafting, and sprocket for drives of three typical sizes.

COST OF DRIVES (1916)

Class	Approximate weight, lbs.	Approximate cost, $
Heavy (large)	2,500	150.00
Medium	1,900	125.00
Light (small)	1,450	100.00

The power demand for transfer chains is small. 5, 7.5, and 10 horsepower are ample for the small, medium, and large tables, respectively.

COST OF MOTORS FOR TRANSFER TABLES (1916)

Power, h. p.	Speed, R. p. m.	Weight, lbs.	Cost delivered, $
5	900	500	160.00
7.5	900	750	245.00
10	900	880	266.00

All motors are of the belted type, complete with base, pulleys, and starting compensator (no compensator included with 5 h. p. motor).

WASTE CONVEYORS

Trough conveyors are used for removing the waste from the various machines. The large or slab conveyors are used to collect the 4 foot and shorter waste from the slasher and trimmer, and convey it to the burner, while small conveyors of the same type or box-like are employed to collect the sawdust from the various machines and carry it into the boiler room, where it is used for fuel.

The cost of conveyors is not uniform because of the differences in sizes and types of chains which may be used, but the following costs are illustrative:

COST OF CONVEYOR CHAINS AND DRIVES (1916)

Purpose	Cost of chains per linear foot of conveyor, $	Weight of chains per linear foot, lbs.	Cost of drive, $	Weight of drive, lbs.
Headsaw (dust)..........	1.75	25	200	3,000
Edger (dust)	1.25	16	100	1,800
Resaw (dust)............	1.75	25	200	3,000
Re-edger (dust)	1.25	16	100	1,800
To boilers (dust)........	1.75	25	200	3,000
Main (slab)..............	4.00	100	275	4,500
To burner (waste).......	3.00	40	275	4,500

The wooden portions of slab conveyors require from 50 to 60 board feet of lumber per linear foot for the portion inside the mill, and as much as from 80 to 90 board feet where trestle work is necessary, as in the case of burner conveyors. The sawdust conveyors require from 15 to 30 board feet per linear foot when laid on the floor of the plant, and from 30 to 50 board feet when elevated. Figuring lumber, labor, and hardware at $20 per 1,000 board feet, the total cost per linear foot is two cents for each board foot. The higher figure in each case represents the heaviest construction ordinarily used.

The rate of speed at which the various conveyors are run is about as follows:

SPEED OF CONVEYORS

Use of conveyor	Fast, ft. per min.	Medium, ft. per min.	Slow, ft. per min.
Headsaw (dust)	70	65	50
Edger (dust)	80	70	60
Resaw (dust)	80	70	60
Boiler (dust)	70	65	50
Main (slabs)	50	40	30
Burner (slabs)	30	25	20

Where slabs are removed from the conveyor for lath or wood, the speeds are regulated to give ample time to take out the pieces.

The amount of power required varies with the length, size, and number of chains, and the amount of material conveyed. Typical power demands are as follows:

CONVEYOR POWER RECORDS

Sawdust Conveyors

Case 1.	Length, 85 ft.; rise, 10 ft. 6 in., 12.4 per cent; 8 x 16 in. chain, 65 ft. per minute:	
	Average	2.2 Kw.
	Partly blocked	7.0 Kw.
Case 2.	Length, 104 ft.; rise, 7 ft.; 6.7 per cent; ½ x 2 x 8 x 12 in. chain, 70 ft. per minute:	
	Average	2.7 Kw.
Case 3.	Length, 60 ft.; rise, 5 ft.; 8.3 per cent; 6 x 8 inch chain, 63 ft. per minute:	
	Average	1.5 Kw.
Case 4.	Length, 80 ft.; rise, 6 ft.; 7.5 per cent; 8 x 16 inch chain, 65 ft. per minute:	
	Average	1.6 Kw.
	Maximum	3.1 Kw.

Slab Conveyors

Case 1.	Main slab conveyor, length, 138 ft.; rise, 32 ft.; 23.2 per cent; chain, ½ x 2 x 8 x 12 inches, 70 ft. per minute:	
	Average	7.0 Kw.
	Heavy	10.2 Kw.
Case 2.	Conveyor for trash under carriage, length, 78 ft.; 6 ft. lift; 7.7 per cent; chain, ½ x 2 x 8 x 12 inches, 70 ft. per minute:	
	Average	1.8 Kw.
	Heavy	2.8 Kw.
Case 3.	Main slab conveyor, length 104 ft.; rise, 9 ft.; 8.7 per cent; double ½ x 2 x 8 x 12 inches; 25 ft. per minute:	
	Average	5.8 Kw.
	Very heavy	9.8 Kw.
Case 4.	Wood conveyor from timber trimmer, length, 110 ft.; almost level; ½ x 2 x 8 x 12 inch chain; 66 ft. per minute:	
	Average	3.0 Kw.
Case 5.	Main slab conveyor from trimmer; length, 100 ft.; rise, 4 ft.; 4 per cent; double ½ x 2 x 8 x 12 inches at 57 ft. per minute:	
	Average	4.2 Kw.
	Very heavy	9.8 Kw.
Case 6.	Main slab conveyor, length, 85 ft.; rise, 9 ft. 6 in.; 11.2 per cent; double ½ x 2 x 8 x 12 inches at 57 ft. per minute:	
	Average	4.3 Kw.
	Maximum	5.8 Kw.

Only these conveyors include motor losses and transmission friction. For all others the inputs are for the conveyors alone with average load conditions. The starting conditions closely approximate those for sorting tables.

CONVEYOR MOTOR COSTS (1916)

Power, h. p.	Speed of motor, R. p. m.	Weight, lbs.	Cost delivered, $
5	1,200	525	195.00
7.5	1,200	835	270.00
10	1,200	930	347.00

Motors are all back geared 7:1 and furnished complete with base and starting compensator. The 5 h. p. motor has a starting switch.

ROLLER BAND RESAWS

Roller band resaws are coming into more general use because of their small operating cost and large capacity. They are used as auxiliaries to the headsaw to reduce the loss in kerf and increase the output of the plant. They may be placed either in the mill or just outside along the grading table (Figs. 5, 14, 27). If only square edged or practically square edged stock is to be put through them, they are usually placed near the grading table. If they are to be used for working up slabs, they are placed in the mill near the headsaw.

Roller resaws are either vertical or horizontal with respect to the position of the board during the sawing operation, or, in other words, the plane of the cutting line. The horizontal type is best suited to working up slabs and material which has not been edged, while the vertical type is best adapted to squared up stock, although the two are more or less interchangeable.

VERTICAL RESAWS

The vertical resaws are of single and twin types, (Fig. 14). The twin type has the advantage of making two cuts at once, and therefore has a much larger capacity, although it is not so flexible as the single band and works to best advantage when used along with a single saw to assist in breaking up thick stock.

Both resaws are quickly adjustable to cants of different thicknesses for the production of boards of different thicknesses, but each delivers its maximum output when sawing stocks of constant size.

The resaws commonly used in fir plants have 60, 66, 72, or 84 inch wheels, and are usually run with saws 6, 8, or 10 inches wide and from 30 to 36 feet long. They are designed to take stock from 12 to 18 inches thick (spread of feed rolls) and from 24 to 36 inches wide (distance between table and saw guide) depending upon the size of machine purchased.

The feed varies from 80 to 225 feet per minute, although faster feeds can be used if larger and heavier saws are installed. This may mean an increase in kerf, and the waste must be balanced against increased output.

The capacity of a vertical resaw varies directly with the feed used, the thickness and width of stock, and the time lost in adjustment, changing saws, etc. The writer has seen as much as 200,000 feet of 2 inch stock from 6 to 12 inches wide come from a vertical resaw in a day, which indicates what one of these machines can do when fast and continuous feeds are used. The usual output at plants where both one inch and two inch stock are sawed is from 40,000 to 60,000 board feet per day.

Vertical resaws are ordinarily run at from 9,000 to 10,000 feet per minute. The tooth space is usually 1¾ or 2 inches, the latter being more common.

SIZES AND COST OF BAND RESAW SAWS (1916)

Width, in.	Gauge	Cost of saws per lineal foot at coast terminals, $	Width, in.	Gauge	Cost of saws per lineal foot at coast terminals, $
6	16	1.14	8	17	1.44
6	17	1.08	9	16	1.62
7	16	1.32	9	17	1.62
7	17	1.26	10	16	1.80
8	16	1.44	10	17	1.80

The above costs are for any tooth spacing, and include brazing and tensioning.

Resaw saws require the same kind of care as headsaws. They must be changed at least twice daily, and should be changed four times if maximum feeds are maintained. When taken off, they are swaged, tensioned, and gummed as their condition demands.

The cost and weight of vertical resaws depends upon their size, style, and make. The following data are illustrative only:

SIZE AND COST OF VERTICAL RESAWS

Diameter of wheels, in.	Size of saw, in.	Weight, lbs.	Approximate cost delivered, $
60	7	11,000	1,800
66	8	13,000	2,000
72	9-10	16,000	2,500
84	10-12	18,000	3,000

Vertical resaws are usually equipped with from 50 to 100 h. p. motors, according to the size of stock to be cut and the feed to be employed. The following power data give an idea of the actual power used in sawing stock of varying widths at a feed of 185 feet per minute.

Average input throughout day	48 Kw.
Maximum instantaneous input	144 Kw,
Maximum sustained input	109 Kw,
Sustained inputs 2 x 4 inch	42 Kw.
Sustained inputs 2 x 6 inch	52 Kw.
Sustained inputs 2 x 10 inch	63 Kw.
Sustained inputs 2 x 14 inch	74 Kw.
Sustained inputs 2 x 16 inch	86 Kw.

The number of men required to operate a typical vertical resaw depends upon the size of the stock and the ease and speed with which the lumber is put into the machine. The resawyer often feeds slow machines alone, or he may have one or even two helpers in front of the machine. If the machine deposits its material upon rolls, no men may be needed behind it, or there may be from one to three, depending upon the method of disposal and the amount of sorting required.

Besides feeding the stock into the machine, the sawyer must adjust the space between the feed rolls for stock of different thicknesses; and at some plants he changes the speed of feed for stock of different widths, although this is seldom necessary where machines are equipped with sufficient power. The sawyer's helper arranges the stock to be fed into the machine where pieces of varying width are being run, and selects it in a way to reduce the amount of adjustment to a minimum. To save time in adjusting the saws, the stock should, wherever possible, be sorted to thickness before going to the resaw.

Where the stock from the resaw does not go back upon the sorting chains as in (Figs. 4, 5 and 6) the helper (offbearer) places the boards on one or more trucks.

HORIZONTAL RESAWS

The horizontal resaw (Fig. 27) is designed primarily for working up slabs and flitches with rounded edges, although it can be used for the same class of work as the vertical resaw, It has the advantage of eliminating the labor in turning the board on edge for feeding into the machine. These machines are usually installed in the sawmill proper, although they may be placed in the remanufacturing section along the sorting chains, like the vertical resaws.

They are made in two sizes, 6 feet or 7 feet in wheel diameter, and take 9 or 10 inch and 10 or 12 inch saws, respectively. The saws can be raised 12 inches and the table lowered 4 or 5 inches, giving a wide range of stock thickness which the machine will accommodate. The feed tables are 36 inches wide. The machines are made with or without divided and adjustable tables. The divided tables (Fig. 27) permit feeding two pieces of different thickness at the same time, but unless there are extra men and good feeding facilities, this can seldom be taken advantage of when fast feeds are used. Divided tables also reduce the amount of adjustment necessary and thus increase the capacity of the machine when mixed thicknesses are fed. The divided roll table is equipped with a steel center guide which can be raised

and lowered between the tables. This is operated by a hand lever placed at the side of the machine. In resawing two thicknesses of lumber at the same time, the center guide is raised to prevent the stock working from one table to the other. When the tables are at the same level, the center guide can be lowered, and material the full width of the table fed into the machine.

The personnel required for the horizontal resaws and their duties are the same as for the vertical saws, as are also the spacing of teeth, speed of saws, and cost of saw blades.

Horizontal resaws are designed with constant or variable rates of feed from 60 to 200 feet per minute, depending upon the make. Sometimes they are fed as fast as 300 feet per minute.

The cost and weight of resaws of various sizes depends upon the make and style, and it is impossible to give more than rough figures.

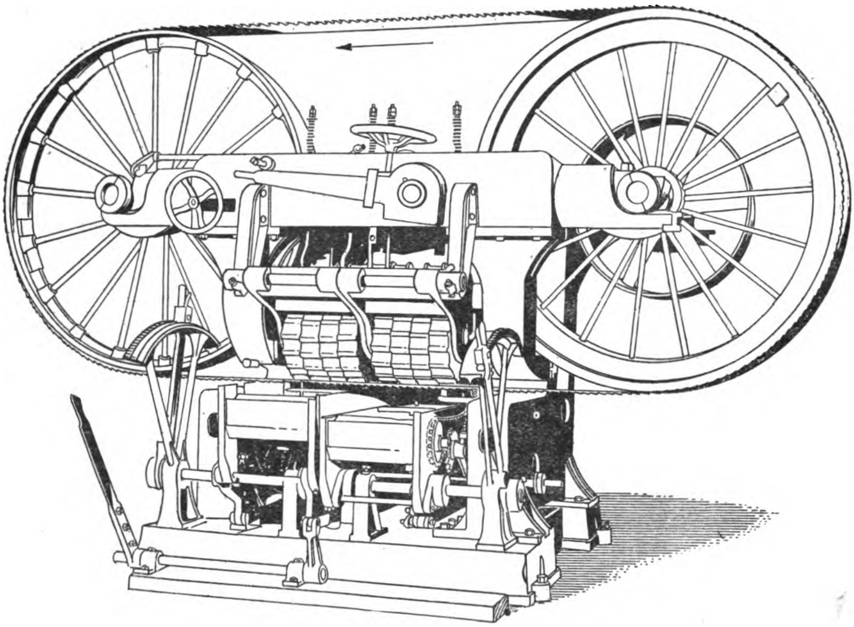


Fig. 27. Right hand horizontal band resaw with divided feed table.

COST OF HORIZONTAL RESAWS (1916)

Size, ft.	Type of table	Weight, lbs.	Approximate cost, $
6	Plain	22,000	2,150
	Divided	26,000	2,550
7	Divided	30,000	2,900

The large horizontal resaws placed in the main mill are usually equipped with from 100 to 200 h. p., since they are often called upon to cut wide cants. No records are available of the power demands on machines of this class, but from the general demand on the vertical resaws, as shown by the data pre viously presented, it would appear that much larger motors are necessary for the wide or double pieces such as the horizontal might receive.

RESAW MOTORS

SIZE AND COST OF RESAW MOTORS (1916)

Power, h. p.	Weight, lbs.	Approximate cost, $
50	2,200	635
75	3,300	880
100	4,600	1,180
150	6,600	1,565

Motors belted complete with base, pulley, drum controller, and necessary starting equipment.

GANG RESAWS

The gang type of resaw (Fig. 15) is used in the Douglas fir mills to reduce round or square edged cants or flitches coming from the head saw or edger into a number of boards or pieces of dimension stock in a single operation. The width of the boards corresponds to the thickness of the cant, and their thickness to the distance between the saws. Ordinarily, these machines are placed on the main mill floor, so that cants may be diverted to them instead of to the edger. They may be placed outside the mill in the remanufacturing plant (Figs. 6 and 15) along the grading and sorting tables. In the latter case they are smaller and are used principally for resawing square edged cants into 4 or 6 inch strips for flooring and similar patterns, and are then called flooring gangs.

The machine shown in Fig. 15 is the style and size ordinarily placed inside the mill and is wide enough to take cants the full width of most logs; the smaller one shown in (Figs. 6 and 15) is used on the narrower and square edged cants.

The gangs are used principally to cut clear cants 3 and 4 inches thick into 1 x 3 or 1 x 4 flooring strips, or 6, 8, 10, and 12 inch cants into 1 x 6, 1 x 8, 1 x 10, or 1 x 12 clear boards for making flooring, ceiling, drop siding, or finish patterns. Sometimes the gangs are used to make dimension lumber (2 inches thick) from cants containing only common lumber; and many of the wide gangs are arranged so that part of the saws are spaced 2 inches and part 1 inch to permit sending both common and clear cants through respective parts of the machine at the same time. When this is not possible, space is often provided to store the common cants when the machine is set for cutting clear 1 inch strips and vice versa when it is set for 2 inch common. The saw settings are adapted to any thickness of stock, but it requires considerable time to change from one to another.

The sawing is accomplished by feeding the cants horizontally against a battery of saws hung vertically in an oscillating sash which runs at the rate of from 250 to 300 strokes per minute, according to the rate of feed and the thickness of stock cut. In the old style of machines the amount of oscillation for given feeds was regulated by the sawyer, but the new machines are equipped with a device which changes the adjustment automatically with different feeds and always insures proper speed.

The cost and weight of the usual sizes of large gang and flooring resaws used in Douglas fir mills are shown below:

SIZE AND COST OF GANG RESAWS (1916)

Maximum thickness, in.	Maximum width, in.	Normal 10-hour cut, bd. ft.	Approximate weight, lbs.	Cost delivered, $
8	32	25,000	17,000	2,000
10	32	30,000	19,000	2,250
12	32	35,000	22,000	2,550
12	40	65,000	35,000	4,250
12	48	80,000	45,000	5,000

These costs are complete with feed-in rolls and an alignment guide for the feed.

SPEED OF FEED FOR GANG RESAWS

Size of gang, in.	Size of stock, in.	Speed, strokes per min.	Feed per stroke, in.
8 or 10 x 32	4	300	½
8 or 10 x 32	8	300	¼
12 x 32	4	275	⅝
12 x 32	8	275	⅜
12 x 32	12	275	¼
12 x 48	4	250	⅞
12 x 48	6	250	¾
12 x 48	8	250	⅝
12 x 48	12	250	½

There are many motor-driven gang saws in successful operation, and if the mill is electrically driven this style of gang is usually preferable to the direct steam cylinder drive. The following power records are illustrative of the demand when cutting typical stock on a 12 x 32 inch machine:

No. 1. Stocks 30 x 8 inches (2 to 4 inch pieces), fir:

Rate of feed	8 feet per minute
Number of saws cutting	27
Working input:	
Average	55.7 Kw.
Minimum	41.1 Kw.
Maximum	62.5 Kw.
Running light input	11.9 Kw.

No. 2. Stock 30 x 12 inches, fir:

Rate of feed	8 feet per minute
Number of saws cutting	27
Working input:	
Average	86.5 Kw.
Minimum	56 Kw.
Maximum	92 Kw.

SIZE AND COST OF GANG RESAW[1] MOTORS (1916)

Size of gang, in.	Power, h. p.	Weight, lbs.	Cost delivered, $
8 x 32, 10 x 32	35	1,900	650
12 x 32	50	2,960	830
12 x 40, 12 x 48	75	3,800	1,070
14 x 48	100	4,600	1,145

These motors have ample power to operate the above machines under usual operating conditions; if abnormal feeds are to be used, the motor sizes must be increased.

[1] Motors of slip ring type belted complete with base, pulley, controller, and resistance.

SIZE AND COST OF GANG SAW SAWS (1916)

Size of Gang, in.	Gauge	Length, in.	Width, in.	Tooth space, in.	Kerf in.	Cost each delivered, $
8 x 32	16-20	24	4⅝	1⅛	⅛-1/16	1.25
10 x 32	16-20	27	5	1⅛	⅛-1/16	1.40
12 x 32	16-18	31	6	1¼	⅛-5/32	1.70
12 x 40	16	34	8	1⅜	⅛	2.25

RE-EDGERS

Many boards which leave the mill and are deposited upon the grading table have wane along the edge or are half inferior and half high grade lumber. Boards of the first kind must be squared up on the edges; the others must be ripped in two. This process is called re-edging, and the work is usually accomplished on a pony edger in the re-manufacturing plant. In some cases this material is sent back into the main mill, where it goes through the main edger again or through a small edger or rip saw used for this purpose,

The re-edgers are small, since the material handled is usually boards and dimension stock. They are of the same type as the edgers used in the pine mills; that is, there is a table in front of the machine and the saws are shifted from the end of the table.

The feed may be as high as from 350 to 400 feet per minute, and the capacity up to 50,000 or 60,000 feet per 10 hour day, but this is seldom needed.

Usually a 4 inch edger is large enough. The machines come in different widths and are equipped with from two to four saws. Two are ordinarily sufficient.

WEIGHT AND COST OF RE-EDGERS (1916)

Size, in.	Number of saws	Weight, lbs.	Approximate cost, $
4 x 32	2	2,800	250
4 x 42	3	3,000	300
4 x 48	4	3,300	350

These costs include both front and back rolls, but no saws or motor.

Re-edger saws are of the inserted tooth type, similar to those used on the large machines but smaller. The rim speed is 9,000 per minute. Their size, weight, and cost are given below.

SIZE AND COST OF RE-EDGER SAWS (1916)

Diameter, in.	Gauge	Kerf, in.	Cost, $
18	7	¼	16.50
20	7	¼	18.50
22	6	¼	21.50
24	6	¼	25.00

The extra teeth for these saws are 2½ cents each.

Re-edger machines can be operated with motors of from 15 to 40 h. p. according to the speed of feed and the size of the machine.

COST OF RE-EDGER MOTORS (1916)

Power, h. p.	Weight, lbs.	Approximate cost, $
15	880	275
20	1,200	325
25	1,320	370
30	1,670	405
40	1,930	465

Motors complete with starting compensators for direct connection.

The machine is fed by one man who pushes each board to a point where it comes in contact with the feed rolls. As the board enters the machine it pushes back the upper hinged rolls, which ride on the top of the piece, force it down against the lower rolls and prevent the stock from being kicked out of the machine by the saws, since the harder the backward thrust, the tighter is the gripping action. Similar rolls at the rear of the machine remove the boards to the rear table, where the offbearer separates the waste from the good boards. Sometimes, however, this offbearing is done by the retrimmerman.

RE-TRIMMERS

A certain proportion of the boards and pieces of dimension stock which come from the main trimmer or from machines used in remanufacturing must be retrimmed. This work is usually done on a small trimmer placed in such a way that the material may be diverted from the grading table to this machine and returned to the table for reclassification after it has been cut.

There are several types of machines which are suited to this work, ranging from a small swing cut-off saw to an elaborate trimmer similar to the main trimming equipment, but having only 12 or 13 saws. A machine which will answer the same purpose and cost much less is shown in (Fig. 28). This trimmer is of the under-cut pedal type and is designed to enable the operator to handle the material himself instead of requiring an assistant. It cannot be used where large quantities of retrimmed stock must be handled but is particularly applicable to the layout referred to above for the retrimmerman can act as offbearer for the re-edger in addition to performing his own duties. The saws are raised and lowered by pedals, and in general the operation is similar to that described for the main trimmers, except that slower feed and smaller saws are used.

The retrimmers of the type shown cost about $1,000 when equipped with 12 saws, (24 foot lumber) and proportionately more for more saws. They come complete with pulleys, chains, and wood work. The twelve-saw machines weigh about 12,000 pounds.

Retrimmer saws are usually 24 or 26 inches in diameter, though larger saws are sometimes used.

SIZE, WEIGHT, AND COST OF RETRIMMER SAWS (1916)

Diameter of saws, in.	Gauge	Cost delivered, $
24	11	8.10
26	11	9.60
28	10	11.10
30	10	13.20

The amount of power required for the retrimmers varies from between 5 and 7.5 h. p. for the single swing cut-off saw type to 30 h. p. for the elaborate pneumatic type. The type shown requires about 20 h. p.

COST OF RETRIMMER MOTORS (1916)

Power, h. p.	Weight, lbs.	Cost delivered, $
5	340	118.50
7.5	600	194.00
10	750	245.00
15	880	285.00
20	1200	339.00
30	1670	427.00

Motors complete with base, pulley, and starting compensator.

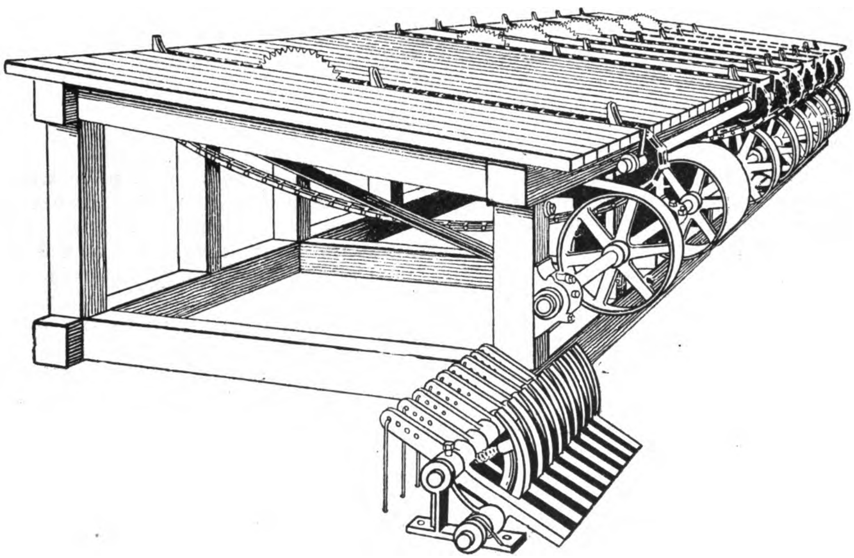


Fig. 28. Retrimmer with pedal saw control.

REFUSE HOGS

Where mills require more fuel for their boilers than can be supplied by the sawdust from the various machines, or where there is a market for "hogged" fuel, a hog is usually installed to chip the waste into small particles. The following table gives the size, capacity, and cost of typical machines.

SIZE AND COST OF REFUSE HOGS

Diameter of drum, in.	Capacity, cords per hr.[1]	Speed, R. p. m.	Approximate weight, lbs.	Cost delivered, $
30	6	1,200	3,000	325
34	10	1,150	4,000	400
36	12	1,000	7,000	650
48	14	850	9,000	750

[1] One cord of slab yields 235 cubic feet of hogged waste.

The following power data from readings on a 48 inch hog are illustrative of the character and amount of the power demand for such machines:

Running light—input	25.0 Kw.
Average input throughout day	50.8 Kw,
Maximum observed (instantaneous)	200.0 Kw.
Maximum sustained input	156.0 Kw.
Kw. Hrs. per cord of fuel	7.9 Kw.

The above were average conditions where the hog was not crowded. The following data were taken during a short test with two men feeding as fast as possible, although the capacity of the hog was not reached.

Average input	77.4 Kw.
Maximum sustained input	160 Kw.
Maximum instantaneous input	240 Kw.

SIZE AND COST OF MOTORS (1916)

Size of hog, in.	Power of motor, h. p.	Approximate weight, lbs.	Cost delivered, $
30	30	1,670	428
34	50	2,300	547
36	75	2,630	742
48	100	4,300	1,100
60	150	6,200	1,450

Motors complete with base, pulley, and starting compensator.

These hogs are fed by hand, and one or several men are required, depending on the volume of material to be fed to the machine. One man can feed from 3 to 4 cords of material per hour. Usually the pieces are picked from the waste conveyor and dropped into the hog, although sometimes the waste from lath machines is deposited directly in a hog instead of going over a conveyor. In this case the labor cost of hogging is negligible.

GRADING AND SORTING TABLES

As the lumber comes from the mill it falls, rolls, or slides upon the grading and sorting tables, where each piece is marked with its grade or order number and placed with other pieces of the same grade and size for transportation to the yard, kiln, cars, or dock. The grading table is usually from 30 to 32 inches high, from 40 to 60 feet long, and from 4 to 6 chains (24 to 32 feet) wide.

The sorting table is in reality a continuation of the grading table. There is usually but one sorting table in a small mill, but in large mills two or three are quite common. Even where more than one sorting table is used, the lumber all passes over one grading table and is then diverted to the various sorting tables by means of live roll or belt conveyors. The sorting tables are ordinarily from 300 to 400 feet long and provide for about sixty segregations on each side. They are from 3 to 6 chains (12 to 20 feet) wide; sometimes they are narrower at the end farthest from the mill because the longest boards are usually sorted as near the mill as possible.

The sorting chains are made as long as possible, for great length increases the number of segregations and eliminates further assortment in the yard. Where sufficient space is not available along the chains, the number of segregations may be increased by using one truck for two sizes of material.

Standard chains (Fig. 26) were formerly used almost exclusively on lumber sorters, but in recent years cables have gradually displaced them. The cables are said to be less likely to break; and when they do break, the sorter is not shut down. A ⅞ inch cable is usually employed. The chief advantage of a cable is that the entire 400 ft. sorter can be driven by a single drive; while if chains are used, a separate drive and motor must be installed each

100 feet because the standard chains are not strong enough to stand the strain when used in longer sections.

The speed of sorting chains varies from about 10 to 65 feet per minute, depending upon their length, and the amount of material to be handled. The chains are usually run as slow as conditions will permit, since the slower they are run the more trucks can be taken care of by each man. Where the chains are divided into sections the speed is sometimes reduced as lumber gets farther from the mill and many of the pieces have been taken off.

The cost of sorting tables is the same as that of any other transfer tables. Where cables are used, the drive for as much as 400 feet of table costs about $700 for four cables and proportionately more for 5 or 6, including all gears, boxes, sheaves, etc. The cables cost about 20 cents per foot.

For short sections of sorting tables, 100 feet or so, a 5 h. p. motor is ample; but where the entire length is driven by a single motor, 10 or even 15 h. p. is desirable for each section. The starting demand is very heavy, and friction drive is essential in order that the motor may get up to speed before the load is applied.

Five-horsepower motors weigh approximately 340 pounds and cost about $120 delivered (1916); 7.5 horsepower motors weigh 600 pounds and cost $194; 10 horsepower motors weigh 750 pounds and cost $245; and 15 horsepower motors weigh 880 pounds and cost $339. Motors complete with base, pulley, and starting compensator.

Many builders make a practice of putting a shed over the sorting table. These sheds are usually 32 feet wide between posts and cost about 10 or 12 cents per square foot. They contain about 3 or 4 board feet of lumber per square foot, exclusive of the floors and substructure.

The labor cost of grading (1913) varies from 2½ to 3½ cents; and of sorting, from 18 to 25 cents per each thousand board feet. Twenty cents is a fair average for sorting where the conditions are at all favorable. The variation depends principally upon the character of the product and the wages paid.

The grader, or marker, puts the grade or order number on each board with crayon, so that the men doing the sorting can tell upon which truck to place it. As the pieces pass along the table, they are watched by the sorters and pulled off upon trucks or into units for the monorail or crane. Where the monorail is used (Fig. 29) and the lumber is to go to the yard for air seasoning, sticks are placed between layers to prepare it for drying and to save the cost of doing this in the yard.

At some plants, where an accurate record of the cut is desired, a tallyman is employed to record each piece. This not only gives a basis for paying contract labor and carrying out bonus schemes, but it furnishes data on the amount of output for use in figuring costs and checking the quantity of material obtained for special orders. Operators who use such tallies find them well worth the small cost involved.

About one man is required to each ten thousand feet of material cut daily; but at plants where the chains are slowed down and there is a large number of trucks, the number of men is greatly reduced.

TIMBER STORAGE SKIDS

Timber storage skids are placed along the loading spur for use in accumulating and handling material for timber orders. One skid is placed opposite each roll in the main section of live or dead rolls leading from the mill. The number of skids depends upon the length of the timber loading spur, which is usually several hundred feet long.

These skids contain from 400 to 700 board feet of material each (i.e., the skid proper above the dock), depending upon their height and length as well as the size of timbers used. If the lumber is figured at $10 and the labor and hardware at $5 per 1,000 feet, the cost per skid is from $6 to $10.

The lumber is distributed along these storage skids by one or several men, who push the sticks from the rolls down the inclined timber. When a carload is assembled at one point a car is "spotted" opposite the skids and the loading begun.

Usually, to faciliate loading, the top of the horizontal skid member is built at an elevation which will permit sliding most of the material downward into gondola cars or upon flat cars.

TIMBER SIZERS

The timber sizer is usually considered part of the sawmill equipment, since it is generally placed at the end of the mill. From an operating and cost standpoint, however, it is a part of the planing equipment.

Machines of this class must be built to stand the heavy work of surfacing large long pieces. They are built to take stock up to 30 inches wide and 16, 20, or 24 inches thick. They are fed at from 20 to 80 feet per minute on big timbers and up to 125 feet on small stock, the speed depending upon the size of stock and the amount of material which must be removed to get the required finished sizes. As much as two inches can be removed from a face if necessary; but, of course, this is seldom done, for the stock is made within one-fourth inch of the correct size on the head saw or edger.

The sizes, weights, and costs of timber sizers are as follows:

COSTS OF TIMBER SIZERS (1916)

Size, in.	Weight, lbs.	Cost delivered, $
12 x 30	21,500	3,400
16 x 30	22,000	3,450
20 x 30	23,000	3,575
24 x 30	23,500	3,675
12 x 20	17,750	2,800
16 x 20	18,500	2,900
20 x 20	19,500	3,050
12 x 24	19,000	2,950
16 x 24	19,500	3,050
20 x 24	20,500	3,200
24 x 24	21,500	3,350

One man can operate one of these sizers as well as the various transfer skids used in conveying the timbers to and from the machine. There are times also when the machine is not being used at all and the operative can assist in other parts of the plant.

The large timber sizers are usually equipped with from 60 to 115 h. p motors, depending upon the maximum thickness of stock to be handled. The following data show the power demand for this class of work on a 16 x 30 inch sizer fed at 80 feet per minute.

Input running light	15	Kw.
Maximum sustained input	66	Kw.
Maximum instantaneous input	97.5	Kw.
7½ x 9⅝ inch stock—Average	65	Kw.
5½ x 11½ inch stock—Average	57	Kw.
7½ x 13 inch stock—Average	69	Kw.

Fifty horsepower motors weigh 2,300 pounds and cost $521 delivered (1916); 75 horsepower motors weigh 2,630 pounds and cost $730; 100 horsepower weigh 3.800 pounds and cost $895; and 150 horsepower motors weigh 4,640 pounds and cost $1,150.

FILE ROOM

CARE OF BAND SAWS

Band headsaws used in cutting Douglas fir logs are changed at least four times a day, oftener if they become dull or if accidents injure the teeth. The change requires about six or eight minutes. In steam-shaft driven mills, stopping the headsaw to change saws usually requires shutting down the en-

tire plant; but in motor driven mills, the headsaw is the only machine stopped at such times. The edger, trimmer, gang saws, resaws, and other machines continue to operate and cut up any accumulated stock.

Few people except band sawyers and bandsaw filers realize the complexity and sensitiveness of the modern band saw. It is described as "a thin ribbon of tempered steel with teeth cut in its edges and made to run belt fashion over two wheels." This simple description is correct, but it does not convey any idea of the difficulties experienced in making this saw run smoothly and produce good lumber, operating at the high speed required.

Snaky lumber is produced when the saw wabbles in the cut. The most frequent cause of this is improper tension. A dull saw will also heat and not run true. Sometimes the teeth are poorly shaped or injured and cause the saw to lead in or out of the cut at certain points. The saw sometimes wabbles because of insufficient strain, but this is seldom the case. If the saw is overcrowded, it will heat and run unevenly.

TENSION

A most important element in successful band saw operation is keeping the correct tension (distribution of metal in the blade) in the saw to insure true cutting, and to keep the saw from slipping off the wheels where no crown is used. The idea of tensioning is to spread the metal in the center of the blade toward the two edges (Fig. 30) so that it is very slightly longer in the center than at the edges. The result is that when the saw is bent as it passes around the saw wheels, the center of the blade bows away from the face of the wheels, thus throwing the effect of the straining device upon

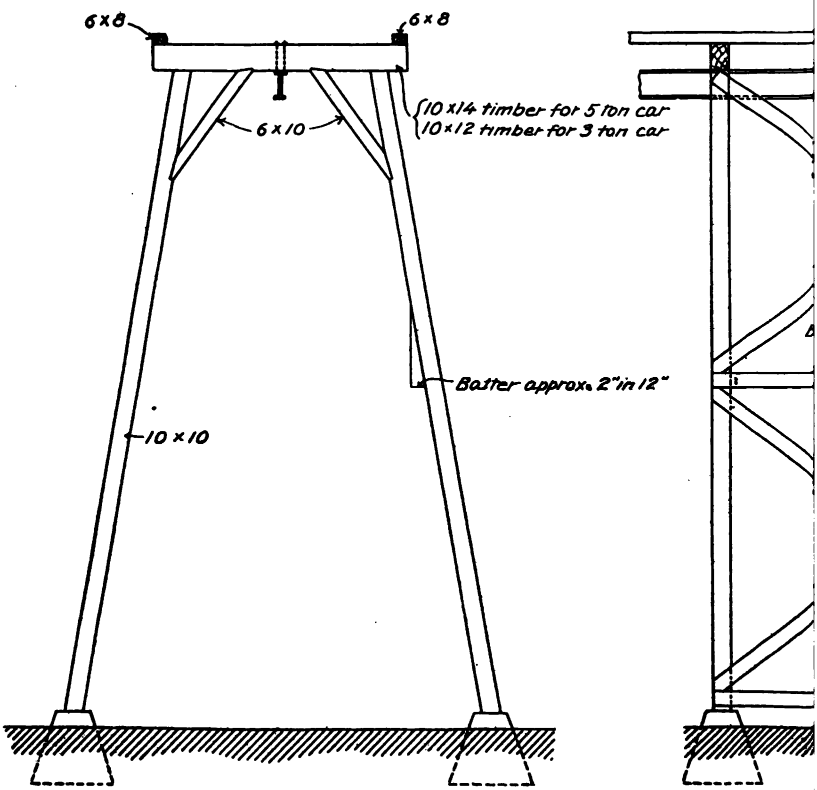


Fig. 35. End and side ele

the edges of the saw, stiffening them, and causing them to run perfectly true.

The tensioning must be done uniformly throughout the saw's entire length. That is, the blade must form from the front edge to the back edge an arc of constant diameter the entire length of the saw, or the edges will not strain uniformly and the saw will not run true.

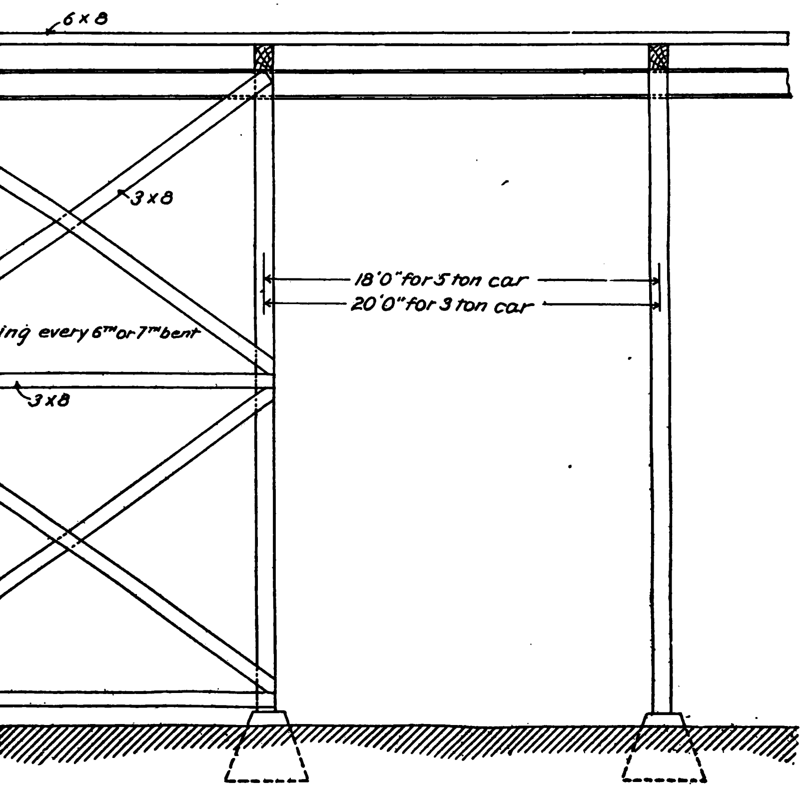
Tensioning is done either by hand with a hammer having a round head and slightly curved face, or by rolling in a special tensioning machine. In hammering, light blows are used so as not to crystallize the steel or injure the saw in other ways.

Saws of various widths and gauges require different tension arcs to do their best work. The arcs which are recommended for each width and gauge of standard Douglas fir band saws are given in the following table:

DIAMETER OF TENSION ARCS FOR BAND SAWS OF VARIOUS WIDTHS AND GAUGES

Width of saw, in.	Gauge,	Diameter of circles having the desired arc, ft.
12	13	40
13	13	50
14	13	50
15	13	55
13	12	50
14	12	[illegible]
15	12	[illegible]
16	12	66

There are slight differences in saws and in operating conditions which often necessitate modification of these arcs to insure the best results. The figures given, however, represent average conditions. A safe rule is to give the saw all the tension it will stand and still lie flat.



ion of monorail runways.

Tension gauges with the above arcs are used in testing for proper tension.

TWISTS AND LUMPS

Twists and lumps are quickly detected by running a straight edge over the saw, and are removed by hammering with special hammers. When detected, they may be marked with chalk to insure their removal before the saw is again used. After such defects have been removed by hammering, the tension is again tested, since it is nearly always affected.

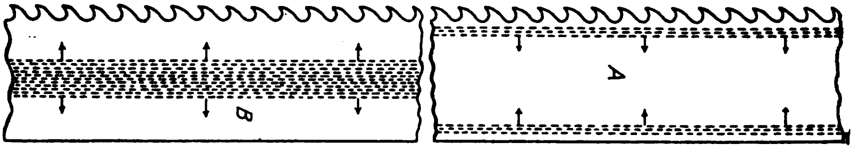


Fig. 30. Tension zones in a band saw. Arrows indicate movement of metal when saws are hammered or rolled.

SAW CRACKS

Small saw cracks which are not immediately arrested will continue to develop and eventually run the width of the saw. A crack may be stopped easily by punching a small hole at its extreme end. Care is necessary to see that the crack does not extend beyond the point where the hole is punched.

SWAGING THE TEETH

Swaging saw teeth consists of spreading the tips or corners of the teeth, so that they are slightly wider than the thickness of the saw (Fig. 31). This is necessary to make the saw kerf wider than the saw, and thus prevent binding and heating in the cut. However, if the swage is unnecessarily wide, it weakens the teeth, causes waste in kerf, and increases the power consumption. As a general rule, the swaged width of the tooth after side dressing is about twice the thickness of the saw.

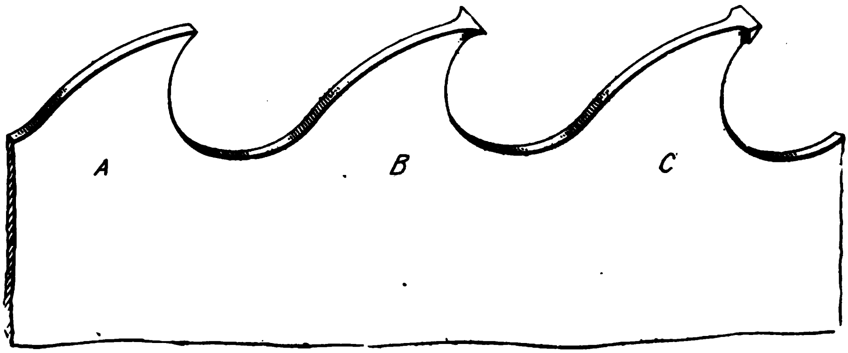


Fig. 31. Stages in swaging.

Band saws are swaged with lever swages, since it is almost impossible to swage them uniformly enough with a hand swage and mallet to insure true sawing. After swaging, the teeth are shaped with a lever shaper to insure uniformity, which is necessary to straight and smooth cutting.

GUMMING

When band saw teeth wear down, the gullet or throat must be ground out to keep the sawdust space uniform in size and the teeth of constant length. This process is called gumming and is usually done by an automatic machine.

The work is accomplished by a rapidly revolving emery wheel whose edge is curved to correspond with the curvature in the tooth gullet. The machine automatically draws the endless saw past the emery wheel so that each gullet is ground the same amount. The emery is applied for a second or so only at a time, so that the metal will not be burned or made brittle. Burning or sharp notches in the gullet are usually the cause of saw cracks.

BRAZING

When a band saw is badly cracked or broken, or when a tooth breaks off back in the throat, a section of the saw is removed and splicing and brazing are necessary. The two ends to be brazed are bevelled about one inch on the surfaces to come in contact when the braze is made. The actual operation is accomplished by the application of silver solder, powdered borax, and heat to the bevelled ends which are held tightly together in a clamp. A braze properly made is said to be stronger and tougher than the rest of the saw.

ORDERING BAND SAWS

The following information is supplied the saw dealer in ordering band saws: 1. Right or left hand mill. 2. Amount of crown on saw wheels (if any). 3. Length of saw in feet. 4. Gauge or thickness of saw. 5. Width of saw in inches. 6. Distance between teeth points. 7. Kind of wood or woods to be cut.

Some saw filers prefer to buy "saw blanks" and cut their own teeth. They also put in the original tension. In ordering band saw blanks, the width, gauge, and length are the only specifications necessary.

CARE OF CIRCULAR SAWS

Practically all circular headsaws in the Douglas fir region are of the inserted tooth type. This greatly reduces the work of the filer, since, except for keeping the saw tensioned and the dull teeth "pointed up," the saws require very little attention. They require no swaging or gumming.

The lower saw is usually changed four times a day, and the upper saw in double cutting mills once or twice a week, depending upon the size of the logs and the use the saw gets. From 500 to 1,000 teeth per month are required for the lower saw and from 225 to 400 for the upper saw.

HAMMERING AND TENSIONING

To run true and make good lumber, circular saws, like band saws, must have their metal properly distributed. The distribution of the metal varies with the speed at which the saw is run. Slow running saws are made thicker in the body (the area midway between the rim and the center) than high speed saws. Hammering the body of the saw (Fig. 18) with a round headed hammer having a slightly curved face will spread the metal toward the rim and center. and open up the saw, so that it will run true at a given speed. After saws have run a while they become bent or dished, and the rim is expanded by the constant heat from friction, so that the body must again be opened up as described above. This accounts for the periodical hammering necessary. To make sure that the body of the saw is opened uniformly all the way around, it is tested with the straight edge. When a circular saw is in proper tension, the body falls away from the straight edge in an arc of uniform curvature at all points.

If a saw runs absolutely true at the rim out of the cut, it is in proper tension; and if it then wabbles in the cut, the trouble is with the arbor, the track, the alignment, the teeth, or something else, but not with the saw tension.

Lumps may be detected easily and quickly with the straight edge, and are marked with chalk to assist in locating them during the hammering process. They are hammered out with a round faced hammer, and a tension test made afterwards.

ORDERING CIRCULAR SAWS

The following specifications are used in ordering circular saws:

1. Diameter of saw in inches.
2. Right or left hand mill.
3. Gauge of saw at center (and at rim if different).
4. Number of teeth or exact tooth space.
5. Style of teeth, and whether solid or inserted.
6. Diameter of arbor hole, also diameter, number, and distance from center to center of pin holes.
7. Number of revolutions at which the saw is to be operated.
8. Kind of wood to be cut.

FILE ROOM EQUIPMENT

Where band saws are used, considerable file room equipment is needed. The file room equipment is so small in mills having no band saws that its cost is on unimportant item. The following equipment is typical where a band head saw, a band resaw, and a gang saw are used.

	Weight, pounds.	Cost (1916)
16 inch band saw sharpener	1,800	$275
10 inch band saw sharpener	1,350	225
Gang saw sharpener	1,100	185
Circular saw sharpener	1,600	250
Saw stretcher	1,350	275
Automatic scarfing machine	500	120
Brazing table	900	135
Open down filing clamps	500	85
Band saw shears	850	120
Forge		50
Miscellaneous		100

In band mills the total cost of file room equipment varies with size of the plant and also with the type of equipment, but fair averages are as follows:

COST OF FILE ROOM EQUIPMENT (1916)

Size of mill, ft. per 10 hr. cut	Cost of file room equipment, $
60,000 to 75,000	1,500
100,000	2,000
150,000	2.500
200,000	3,000
250,000	3.600
300,000	4,000

These costs cover installation (about 5 per cent) but do not include motors.

COSTS OF FILES AND EMERIES

The costs for files and emeries varies from one-half to one cent for each one thousand feet of lumber produced in the sawmill, depending upon the character, number, and kind of saws.

COST OF FILING

The labor cost is from 7 to 13 cents per thousand board feet of cut, depending upon the kind of filers required and the capacity of the plant. The high figure is for small band mills. The average for the region is close to 9 cents per thousand board feet.

POWER FOR FILE ROOM

Small 7.5 to 15 h. p., 1,800 R. p. m. motors furnish ample power for file room equipment. Usually the shafting is arranged so that one motor will drive all of the equipment, although independent drive for the various machines is sometimes advisable.

FILE ROOM MOTOR COSTS (1916)

Power, h. p.	Weight, lbs.	Cost delivered, $
7.5	600	194.00
10	750	245.00
15	880	285.00

Motors complete with base, pulley, and starting compensator.

COST OF SAWS, BELTS, AND LUBRICANTS

SAWS

The initial cost of saws for Douglas fir mills varies according to the size of plant and whether the head saw and resaws are band or circular. Typical investments for plants of representative sizes are shown below:

ESTIMATED INITIAL SAW COSTS FOR FIR MILLS (1916)

Size of mill (10 hr. cut) bd. ft.	High, $	Medium, $	Low, $
60,000	1,200	1,000	800
75,000	1,500	1,200	900
100,000	2,000	1,800	1,500
150,000	3,000	2,500	2,200
250,000	3,300	3,000	2,500
300,000	5,000	3,500	3,200

These costs include rip and trimmer saws in the planing mill, drag saws on the pond, and the like.

SAW REPLACEMENT COSTS

The replacement costs, exclusive of labor, for saws and saw teeth for each thousand board feet of lumber cut are from 5 to 10 cents. The average is close to 6 cents (1913) for the region as a whole. The difference between the costs at band and circular mills is not more than a cent or so per thousand in favor of circular mills. The high figures are for the costs at plants where the saws are rapidly dulled or frequently broken, as where logs are "driven" to the mill, thus picking up stones and other objects which are hard on the saws.

BELTS

Many mills in the fir region use a variety of belting, such as leather, rubber, and canvas; others use leather throughout. For this reason it is difficult to present data on the investment in belts for mills of different sizes. The following estimates, however, will serve as a guide for calculating initial belt investments.

INITIAL COST OF SAWMILL BELTS (1916)
(Mixed leather, rubber, and cotton)

Size of mill (10 hr. cut) bd. ft.	Shaft driven, $	Motor driven, $
60,000	1,400	800
75,000	1,700	900
100,000	2,300	1,200
150,000	2,900	1,500
250,000	3,500	1,800
300,000	4,000	2,000

INITIAL COST OF PLANING MILL BELTS (1916)

Size of planing mill (10 hr. cut), bd. ft.	Shaft-driven, $	Motor-driven, $
30,000	600	300
50,000	1,000	500
100,000	1,600	800

These figures are probably fair averages and should be modified to meet any unusual conditions of installation. They do not include conveyor belting.

BELT REPLACEMENT COSTS

The belt replacement costs are usually calculated in terms of lumber cut. They are less for electric than steam plants and less in large than in small mills. At all of the small plants and most of the others the belt repairing is done by the millwright and the labor costs are charged in with his usual work, so that belt replacement cost is commonly figured as simply the cost of the belts. While this is not good practice from an accounting standpoint, it makes the cost figures comparable at all plants and is therefore used here. It is estimated that one man can be kept constantly busy on belts alone at a mill cutting 200,000 feet in 10 hours. The belt replacement cost (1913-1915) per 1,000 feet is about as follows:

Shaft-driven sawmills	$0.05 per 1,000 feet cut
Motor-driven sawmills	.03 per 1,000 feet cut
Shaft-driven planing mills..........	.04 per 1,000 feet machined
Motor-driven planing mills..........	.02 per 1,000 feet machined

Belts costs depend on the character of the belt, i. e., whether it is leather, rubber, or canvas. The tabulation below gives the cost of belts of various sizes and kinds.

COST OF VARIOUS BELTINGS (1916)
(Price per foot)

Width in in.	Leather, 1 ply	Rubber, 4 ply	Rubber, 6 ply	Canvas, 6 ply
4	$ .53	$0.25	$0.30	$0.19
5	.66	.30	.46	.23
6	.79	.36	.54	.27
7	.92	.42	.62	.31
8	1.06	.48	.72	.36
9	1,19	.53	.80	.40
10	1.32	.60	.89	.45
11	1.40	.66	.98	.49
12	1.58	.72	1.07	.54
14	1.85	.84	1.27	.70
16	2.11	.98	1.47	.79
18	2.38	1.11	1.66	.89
24	3.17	1.54	2.31	1.18
30	3.96	2.00	3.00	1.62
36	4.75	2.46	3.69	1.99
42	5.54	2.92	4.39	2.45
48	6.34	3.36	5.08	2.80
54	7.13	3.85	5.77	
60	7.92	4.32	6.47	
68	9.79	4.80	7.17	
72	10.37	5.30	7.87	

Note: To obtain 2 ply leather costs double above figures.
6 ply rubber = 2 ply leather
4 ply rubber = 1 ply leather
6 ply canvas = 1 ply leather

LUBRICANTS

The labor cost for oiling in the sawmill alone amounts to from 2 to 4 cents for each one thousand board feet cut. The average cost (1913-1915) for work of this class is close to 3 cents. The planing mill machines and equipment are usually oiled by the men or the foreman.

The total cost of oils and grease per thousand board feet is about as follows:

COST OF OILS AND GREASE

Use	High, $	Medium, $	Low, $
Sawmill, Power plant, Machine shop } per 1,000 feet cut	.05	.03	.02
Planing mill, per 1,000 feet dressed	.03	.02	.01

Some of the larger plants have elaborate oil storage and measuring equipment similar to that in use in public garages. This reduces the fire risk and gives an easy check on the quantity of the various kinds of oils used. The latter is important where detailed oil costs are kept. The equipment cost from $500 to $800 installed (1916) depending upon the number of oils provided for.

MISCELLANEOUS SUPPLIES

The expense for miscellaneous supplies, other than belts, saws, saw teeth, and lubricants, which are discussed elsewhere, usually amounts to from 3 to 10 cents (1913) per thousand board feet of lumber cut. These miscellaneous supplies include babbitt, gaskets, light bulbs, and similar materials.

COST OF INSTALLING MILL EQUIPMENT

The cost of installing sawmill machines and equipment is usually estimated as a percentage of the total delivered cost. The rate used ranges from 10 to 15 per cent, depending upon the size of the mill and the wages millwrights are receiving at the time the work is contemplated. Some contractors will undertake the work on a basis of a cent to a cent and a half per pound, (1913) on the total weight of the equipment installed.

COST OF SAWING

LABOR

The total labor cost of sawing Douglas fir (including all operations from the log deck to the sorting table) varies from 50 to 90 cents per thousand board feet of lumber cut. This cost includes the wages of the mill foreman but excludes filing and oiling costs and all overhead, power, and other costs chargeable to the operation as a whole and not specifically to the mill. The average labor cost for the region for sawing is probably about 65 cents per thousand board feet. The total cost varies with the character of the product (whether largely 1 inch and 2 inch lumber or principally timbers and ties are produced) and whether or not the mill is equipped and powered to obtain the maximum output from a given labor cost.

REPAIRS

The cost of keeping Douglas fir sawmills in repair varies from 2 to 3 cents per thousand board feet in very new plants with efficient equipment to 60 or 75 cents in old plants which are worn out and have inefficient equipment. The repairs for the region as a whole are normally from 25 to 35 cents (1913) per thousand feet. These costs include both labor and material used in repairs.

MOVING LUMBER WITHIN THE PLANT

Douglas fir mills use many methods and devices for moving lumber from one department to another, too many in fact to permit a complete discussion of each. An attempt is made, however, to give data on methods and costs of the more important schemes. General important types of equipment, such as overhead and locomotive cranes and monorails, though they have other functions than transportation, are included in this chapter in order that the discussion of methods of utilizing them and of investment costs may be simplified.

SMALL TRUCKS

There are three styles of lumber trucks in general use in the fir region. The two wheel types are the most common because they are the cheapest. The standard two wheel trucks cost (1916) from $15 to $18 each, and the four wheel trucks from $30 to $35. The four wheel type is more efficient and is usually given preference when funds will permit. When two wheel trucks are used much lumber is broken or damaged (by dragging), and the life of the planking or tramways and docks is greatly reduced. The loads vary in size from 1,000 to 2,000 board feet, depending on the length of the stock. In practice there is no material difference in the capacity of the two kinds, but the four wheel type requires less care in loading and is more rapidly hitched to teams or tractors, since the stakes eliminate the necessity of long cumbersome chains to hold the load in transit.

WAGONS AND AUTO TRUCKS

When small trucks like those just described are not used, the material may be taken to the yard on specially constructed wagons or auto trucks. The lumber at the sorting chains is placed on stationary horses designed to permit backing the vehicle under the lumber units so that it is automatically loaded. The lumber is then taken to its destination and either rolled upon saw horses or dropped upon the tram to await piling. This system does away with the investment in a large number of trucks, and is said to make possible more rapid movement of the loads from one point to another. Autos are preferable to horse drawn wagons. They are faster, the motive power is available for loading and unloading, and there is less expense during periods of shut down.

TRACTORS

Formerly, the lumber trucks were drawn exclusively by horses, but electric and gasoline tractors (Fig. 32) have now come into extensive use. The tractor has several advantages over horses, chief of which that the greater speed of the tractor enables one tractor and driver to do the work of from three to six teamsters and horses; that the life of planking on docks and tramways is about doubled by the elimination of the damage done by the sharp calks in the horses' shoes; that the tractors may be backed into tight places, whereas horses, with the usual equipment are able to move the load forward only.

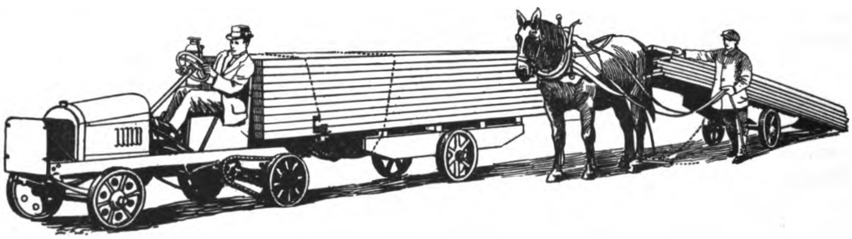


Fig. 32. Gasoline tractor and method formerly employed.

There are several types of electric tractors, all equipped with hard rubber tires and operated by means of storage batteries. They are said to have several advantages over gasoline tractors, chief of which are that there is no expense for gasoline and cylinder oil, the fire hazard is smaller, and the mechanism simple. Their disadvantages are reduction in power through exhaustion and aging of the batteries and expense for new batteries. The cost, weight, etc. of three representative kinds of electric tractors are as follows:

COST OF ELECTRIC TRACTORS

Item	I	II	III
Initial cost	\$2,000-\$3,000	\$2,500-\$3,000	\$1,600-\$2,600
Weight (lbs.)	4,500- 5,000	3,500- 4,500	1,900- 3,800
Size of tires	4/22x4½ in.	1/36x5 in.	4/20x3½ in.
Cost of tires .... (per set)[1]	\$96	\$96	\$80
Initial cost of charging equipment:			
Direct current	\$100-\$175	\$75	
Alternating current	\$300-\$375	\$275	
Annual cost of batteries	\$300-\$325	\$280-\$365	

[1] Tires cost about one cent per mile.

Several kinds of gasoline tractors are now being successfully used. Most of them are modifications of inexpensive automobiles. They are said to be faster than the electric machines and are probably more powerful than most of them.

Gasoline tractors cost from \$800 to \$1,000 each (1916). They consume from six to ten gallons of gasoline and about a quart of oil per day. The solid rubber tires cost about \$85 a set and are good for from 10,000 to 15,000 miles. A tractor will displace from three to six horses and teamsters, depending upon the distances to be covered. The later designs are specially geared to give better variations of speed and thus meet working conditions better.

SURFACE CARRIERS

There are machines which are designed to carry the lumber instead of hauling it. One type is shown in Fig. 33; the other is an ordinary auto truck equipped with a roller bed for loading and unloading the units. These carriers can be operated at the speeds used by industrial trucks in other commercial work and are faster than tractors, which cannot proceed faster than a safe speed for the two wheel trucks.

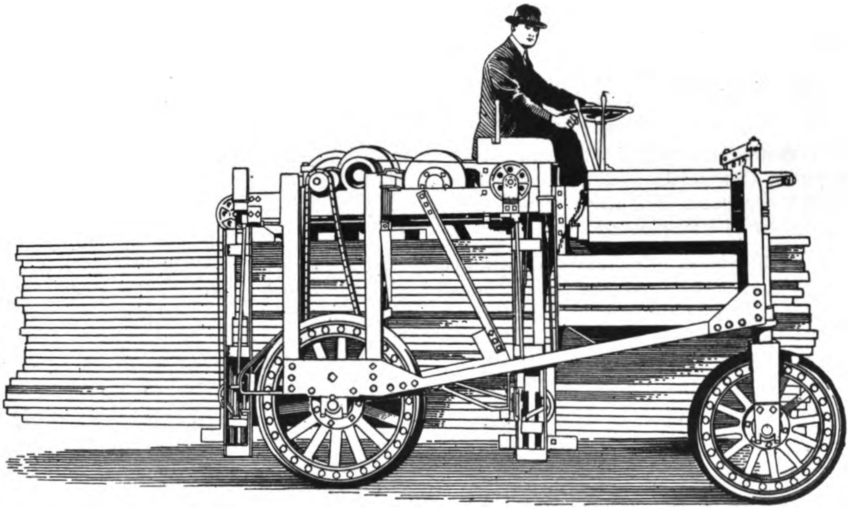


Fig. 33. Lumber carrier.

The type of carrier shown in the figure is made especially for carrying lumber prepared in units and suspended under the machine. It is designed to operate with either gasoline motor or electric batteries. The lumber units are prepared on bolsters like those used for monorails (Fig. 29). The bolsters rest on small blocks of wood a few inches high to enable the operative to engage the grapple hooks. The machine is driven over the unit, quickly grasps and raises the load a few inches off the ground, and then conveys it rapidly to its destination. This machine will carry loads 4½ feet high, 3½ feet wide, and any length. The load is moved on rubber tires and the wear on planking is reduced to a minimum, but means are necessary at the planing mill to raise the loads to a working level.

TRAMWAYS AND PLATFORMS

Typical tramway construction is shown in Fig. 34 except that the planking ordinarily runs across the direction of traffic instead of with it as shown. Running it in the direction of traffic reduces the cost of maintenance, since only the worn boards in the center must be replaced. In addition it eliminates most of the vibration caused when loads are moved rapidly over a cross-planked tram. The cost of constructing 20 foot and 24 foot standard trams is shown in detail below.

COST OF TRAMWAYS

[Material and cost (1916) for each 20-foot bent, lumber at $10 per 1,000]

24-foot Tramway		
Caps: 1 pc. 6 x 12-24	144 bd. ft.	$ 1.44
Stringers: 2 pcs. 12 x 12-20	480 bd. ft.	4.80
1 pc. 10 x 12-20	200 bd. ft.	2.00
Joists: 10 pcs. 4 x 12-24	960 bd. ft.	9.60
Planking: 24 pcs. 4 x 12-20	1,920 bd. ft.	19.20
Total for 20 linear feet	3,704 bd. ft.	$37.04
Per linear foot	185 bd. ft.	1.85
3 20-ft. piles @ $2.70 installed ($8.10), per linear foot		.40
Labor and hardware @ $8.00 per 1,000 ft. ($29.63) per linear foot		1.48
Total per linear foot		$3.75
20-foot Tramway		
Caps: 1 pc. 6 x 12-20	120 bd. ft.	$ 1.20
Stringers: 2 pcs. 12 x 12-20, 10 x 12-20	680 bd. ft.	6.80
Joists: 10 pcs. 4 x 12-20	800 bd. ft.	8.00
Planking: 24 pcs. 3 x 12-20	1,440 bd. ft.	14.40
Total for 20 linear feet	3,040 bd. ft.	$30.40
Per linear foot	152 bd. ft.	1.52
Piles ($8.10), per linear foot		.40
Hardware and labor ($24.20), per linear foot		1.21
Total per linear foot		$3.13

Wood block paving is coming into considerable use as a surface for tramways in the yards and on the docks of Douglas fir mills. Untreated green blocks are used, and their tops are flushed with hot tar or creosote after the pavement is completed.

The blocks can be made of low grade and short length material ordinarily wasted, and they present a surface which will stand many times the wear of the ordinary planking. In fact, it is very probable so long as present methods of laying are used that decay will cause replacement sooner than mechanical wear. If creosoted planking and creosoted blocks were used, the trams would last the life of the mill and need little or no repairing.

From data obtained at various plants, the cost of replacing the planking on trams and platforms where horses are used appears to be on the average from 8 to 12 cents per thousand feet of lumber transported to each department. Under average plant conditions this amounts to about 10 cents per thousand transported, or close to 18 or 20 cents per thousand cut. These costs are about equally divided between lumber and labor.

Where tractors are used instead of horses, the above costs are cut about in half.

The cost of moving lumber within the plant by means of trucks and surface carriers ranges from three to twenty cents per thousand feet of stock moved from one department to another. The average cost (1913) where horses and trucks are used is close to 10 cents for each thousand feet moved.

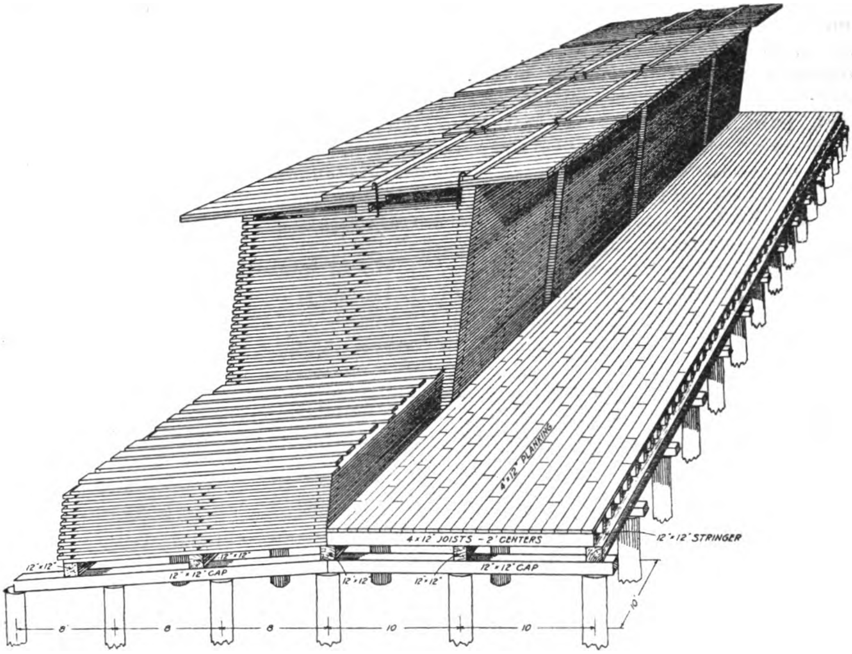


Fig. 34. Method of piling dimension lumber and of constructing tramway. Movable foundation timbers to accommodate lumber of different lengths.

MONORAIL CONVEYING AND PILING SYSTEMS

There are several electric monorail installations at Douglas fir mills for transporting the lumber about the plant and handling it in the yard, sheds, and planing mills. If properly used in connection with large operations, they are undoubtedly much cheaper than ordinary methods. The equipment and method of installation are shown in Figs. 29, 35[1] and 36[2]. The figure shows the usual practice of running the monorail along either side of the sorting chains. It also shows the monorail carrier on a transfer crane, which is used where there is more than one sorting table and at other places requiring right angle movement of the carrier to enter the various tracks. This same type of crane transfer can be used along the planing mill in front of sheds or at the end of runways leading into the monorail tracks in the seasoning yard. Sheds may be constructed over the monorail for storing dry stock (rough or dressed) or for protecting the material in the yard from the weather during the air drying process.

The lumber is placed in square piles, or units, as they are called, containing from 1,500 to 2,000 (3 ton carrier) or from 2,000 to 3,000 (5 ton carrier) board feet each. The piles are made from 3½ to 5 feet wide and from 30 to 50 inches high when piled solid. Each unit is centered directly under the monorail track, so that it will balance when picked up by the carrier. Each unit rests on two 4 x 4 inch (3 ton) or 5 x 5 inch (5 ton) bolsters,

[1] On pages 76 and 77.
[2] On pages 92 and 39.

which are spaced on 4 to 6 foot centers and rest on skids in such a way that each of their ends may be easily engaged by the grapple hooks. These bolsters are a permanent part of the unit until it is dismembered. They separate the units as they are placed one upon the other in the yard or shed. Where the lumber is to go to the yard for air seasoning it is usually "stuck" at the sorting chains with 1 inch by 2-4 inch by 4 foot stickers.

The hoists or carriers are ordinarily built in sizes of either three or five ton capacity, although larger sizes can be obtained. Each is equipped with two motors, one for hoisting and lowering, and the other for travel. The vehicle runs on a special 15 inch I—beam track and is suspended by three four-wheel trucks. The raising and lowering cables are suspended from one (two point suspension) or two (four point suspension) drums. The two drum type is superior, since the control is more positive at all times and there is no teetering to delay the operative in engaging the grapple hooks.

The frame carrying the grapple hooks is equipped with a table to permit turning the load at right angles before running along narrow runways and for storing at right angles to the track.

The amount of material which can be stored beneath each foot of monorail track depends upon the height of the superstructure, the length of the stock, and whether it is piled solid or stuck. Usually 2,700 feet of solid stock and from 1,500 to 2,000 feet of "stuck" stock can be stored to each linear foot of track.

The operative sits in the cage and controls the entire operation of this machine by means of easily reached levers. Sometimes he is given a helper to expedite engaging the units and looking after the bolsters, but this is seldom necessary.

Some of the advantages claimed for the monorail are that it does away with tramways, horses, tractors, and trucks, or buggies; that it handles and transports lumber cheaply and speedily; that it permits getting at the bottom of piles at little cost and thus increases the savings on freight by making possible the shipment of the dryest lumber at all times; and that where the mill generates its own electrical power, the outlay is small compared to the expense for power for other handling and transportation devices.

Following is a summary of the important parts of monorail equipment and their cost.

COST OF MONORAIL EQUIPMENT (1916)

Item	3-ton equipment	5-ton equipment
Initial cost delivered	$3,200	$3,500
Weight in pounds	13,520	14,000
Metal for monorail runway (per linear foot)	$2.50	$2.50
Weight of above (per linear foot, in pounds)	35	55
Switches (complete)	$300	$300
Weight of switches (in pounds)	3,500	3,500
Transfer crane	$2,750	$2,740
Weight of transfer crane (in pounds)	24,000	24,000
Metal for crane, runway (per linear foot)	$1.75	$1.75
Weight of above (per linear foot in pounds)	47	47

A list of the material for the wooden portion of the single track runways is shown below. The labor and hardware for installing these wooden frames is (1916) about $7.50 per thousand board feet.

TIMBERS FOR A 3-TON MONORAIL RUNWAY
[20 Feet Between Bents]

	bd. ft.	
2 pcs. 10x10-30	500	
1 pc. 10x12-12	120	
2 pcs. (Fn.) 6x10-6	60	
Total for one bent	680	
Per linear foot		34.0
8 pcs. 3x8-24	384	
4 pcs. 3x8-20	160	
Side braces for every 120 ft.	544	
Per linear foot		4.5
2 pcs. 6x8-20 top timbers	160	
Per linear foot		8.0
Total per linear foot		46.5

TIMBERS FOR A 5-TON MONORAIL RUNWAY
[18 Feet Between Bents]

	bd. ft.	
2 pcs. 10x10-30	500	
1 pc. 10x12-12	120	
2 pcs. 6x10-6	60	
Total for one bent	680	
Per linear foot		37.7
8 pcs. 3x8-24	384	
4 pcs. 3x8-20	160	
Side braces for every 108 ft.	544	
Per linear foot		5.0
2 pcs. 6x8-18	144	
Per linear foot		8.0
Total per linear foot		50.7

For 3-ton equipment the hoisting speed is 40 feet per minute loaded and 65 feet empty, and the lowering speed is 80 feet per minute loaded and 65 feet empty. For 5-ton equipment the hoisting speed is 25 feet per minute loaded and 40 feet empty, and the lowering speed is 50 feet per minute loaded and 40 feet empty.

The capacity of monorail carriers depends on their size, the length of haul, and the skill of the operator—also upon the number of switches, curves, and other obstacles that retard the speed. Ordinarily, a single carrier can handle from 100,000 to 125,000 board feet daily. At a plant cutting about 200,000 in 10 hours, a single carrier is handling the entire output from a three chain sorter to the kilns and to the planing mill, in addition to stacking all rough kilned stock in a single track dry shed and loading trucks for the seasoning yard. At another plant cutting 125,000 feet per day, all No. 1 Common yard stock is carried to the yard, stacked, and delivered to the cars by a single carrier.

MONORAIL LUMBER HANDLING COSTS

The costs of handling lumber by means of a monorail are tabulated below. The figures are derived from costs at five plants.

COSTS OF HANDLING LUMBER BY MONORAIL

		Handling cost			
Month, 1914	Amount handled in and out, board feet	Sticking,[1] per 1,000 bd. ft.	Labor transportation,[2] per 1,000 bd. ft.	Int. and dep. transportation, per 1,000 bd. ft.	Total transportation
April	1,950,000	$0.242	$0.048	$0.035	$0.083
May	2,159,000	.219	.044	.023	.067
June	1,907,000	.248	.049	.033	.081
July	2,256,000	.209	.042	.028	.070

[1] Labor for sticking; 7 men on the sorting chains at $2.50 per day; not including graders or tallymen.

[2] Labor transportation; one operator for trolley at $3.50 per day.

LUMBER COMPANY'S COSTS BASED ON FIVE MONTHS' AVERAGE

Amount handled per 1,000 board feet	Men and daily wage	Daily cost	Cost at sorter, Per 1,000 bd. ft.	Monorail cost	Total Per 1,000 bd. ft.
65,000	5 men @ $2.25	$11.25	$0.1725	$0.065	$0.2375
80,000	7 men @ $2.25	15.75	.1975	.05	.2475
100,000	9 men @ $2.25	20.25	.2025	.04	.2425

Note. Tallymen or graders not included in above. Monorail operator paid $3.25 to $3.50 per day.

Month, 1915	Total cut	Total hours	10 hours average total	Monorail to yard	Total cost	Cost per 1,000
August	2,293,113	222	103,293	1,185 M	$78.00	$0.065
September	2,398,389	219½	109,266	1,391 M	81.25	.058

August sorting cost, $0.348; September sorting cost, $0.331.

Note. Entire cost of operation, monorail charged against lumber to yard. No credit for lumber returned.

ELECTRIC LOCOMOTIVES AND CARS

Locomotives and cars have so far been little used at Douglas fir mills. This is probably because only very few of the fir mills have large seansoning yards with sufficient trackage. The increasing tendency toward large seansoning yards indicates that locomotives may be more extensively used as time goes on.

This type of hauling equipment (Fig. 37) eliminates the expensive maintenance of planking and makes possible greater speed and fewer operatives;

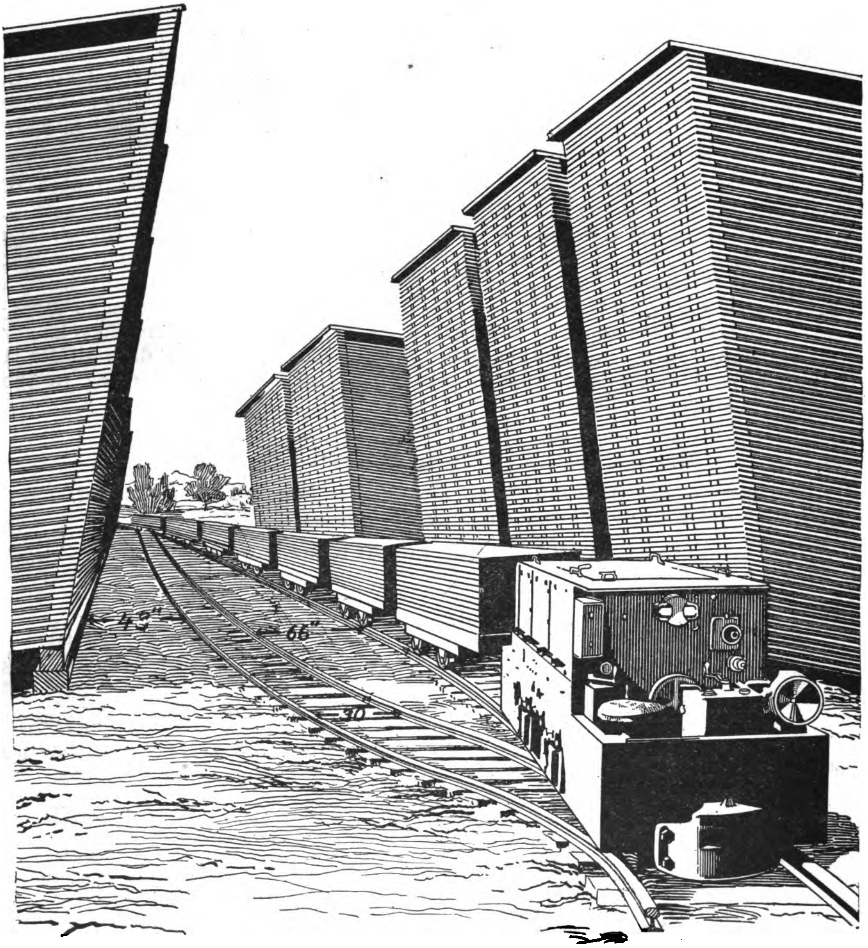


Fig. 37. Miniature electric locomotive for lumber hauling (cab removed).

but the system is not elastic. The cars cannot be operated except where tracks are laid, and even double tracks with numerous switches do not give the flexibility of the two wheel trucks, since considerable switching is necessary to get around loaded cars awaiting the pilers.

The initial cost of electric locomotives (6-ton size) delivered is from $3,200 to $5,000 (1916). The weight is from 3,600 to 3,800 pounds, and the draw-bar pull from 2,400 to 3,500 pounds. The initial cost of the battery is from $1,625-$2,100 (1916).

A mill operator using this equipment states that the cars cost $32 each (1916) and that he is using 600 of them. His output is 100,000,000 feet a year. He also states that the track can be installed complete (gauge 30 inch—ties 8 inches by 8 inches by 4 feet), except the steel and grading, for about $500 per mile. The steel costs from $40 to $50 per ton.

OVERHEAD CRANES

Overhead electric traveling cranes are coming into use at Douglas fir mills, particularly for handling and loading heavy planks, ties, and timbers. These machines are also used to handle units at planer storage rolls and at other such points as the arrangement and operating conditions permit. They are ordinarily made in 3 and 5 ton sizes and sometimes larger, and for any reasonable span.

They are operated to best advantage with a crew of three men, although sometimes two are sufficient. The movements of the crane are controlled by the operative in the cage. He is assisted by a hooktender, who arranges the slings or tongs and engages the load or loosens it. Where two assistants are employed, one stays at the point where the lumber is picked up so as to have the sling in readiness when the crane returns, and the other remains at the point where the loads are being deposited. This saves time and is not so hard on the hook tender, since he does not have to chase the crane.

From close observation of one of these machines at work, the writer believes that a small mill laid out in general according to Fig. 38[1] could handle almost its entire output with a traveling crane much more cheaply than by present methods. The crane can be equipped with grapple hooks and turntable similar to the monorail carrier, so that the cage operator can engage and deposit the load without assistance, and turn it at any angle.

The principal advantages claimed for overhead cranes are: that they have a quick and positive movement in three directions (as against two for the monorail); that they can be used for loading timbers and lumber in addition to storing and conveying; and that they are like the monorail in cheapness of operation.

The initial factory cost of a 3 ton overhead crane (76 foot span) with turntable grapples and two drums is $5.500, (1916) and the weight is 53,000 pounds. The same crane without turntable, grapples, and drum weighs 40,000 pounds and costs $4,500. For a 5 ton crane the cost is $6,000, and the weight 60,000 pounds with the equipment mentioned; without this equipment the cost is $5,000, and the weight 45,000 pounds. For both sizes of cranes the runway metal weighs 47 pounds and costs $1.75 per linear foot.

For 3 ton and 5 ton cranes the speed along runways is 300 feet per minute loaded and 400 feet empty, across the bridge it is 150 feet and 200 feet, respectively, in hoisting it is 35 feet and 50 feet, and in lowering 70 feet and 50 feet. These speeds may be increased if desired.

The cost of the wooden structure and installation of a typical overhead crane is given on the next two pages. These data were compiled by E. E. Martin, Eugene, Oregon, and contain unit figures needed in estimates for such work.

[1] On pages 108 and 109.

UNIT COSTS OF AN OVERHEAD CRANE (1916)

Engineering and supervision @ 1.35 per cent of total cost		$ 118.70
Substructure:		
130 piles @ $0.967 each	$ 125.70	
12,192 ft. of caps @ $9.00 per 1,000	109,73	
Expense (grease, lines, ropes, etc.) @ $0.633 per piling	82.27	
144 drift bolts @ $0.07 each	10.08	
Labor (driving and capping) @ $3.05	396.57	724.35
Concrete piers (33—16x16-40-40x40; (5—16x28-40x40x52:		
Forms (38)		
3,196 ft. of lumber @ $5.00	15.98	
Nails	3.22	
Labor @ $0.84 per form	31.91	51.11
Concrete:		
193 sacks of cement @ $0.71 each	136.92	
20 cubic yards sand @ $1.75	35.00	
67 cubic yards gravel @ $1.00	67.00	
Expense @ $0.019 per cubic yard	.84	
Labor (Excavation and pouring @ $5.238 per cu. yd.)	235.72	475.48
Bracing substructure:		
2,688 ft. of lumber @ $9.00 per 1,000 board ft.	24.19	
Labor @ $2.846 per 1,000 board feet	7.65	31.84

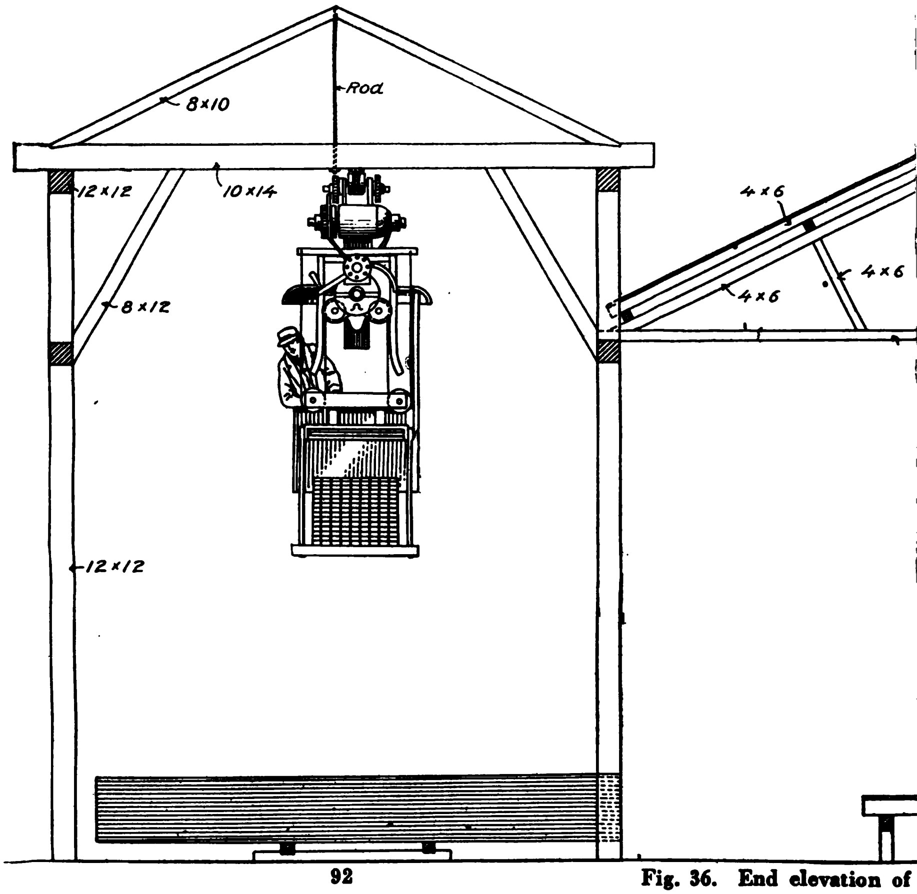
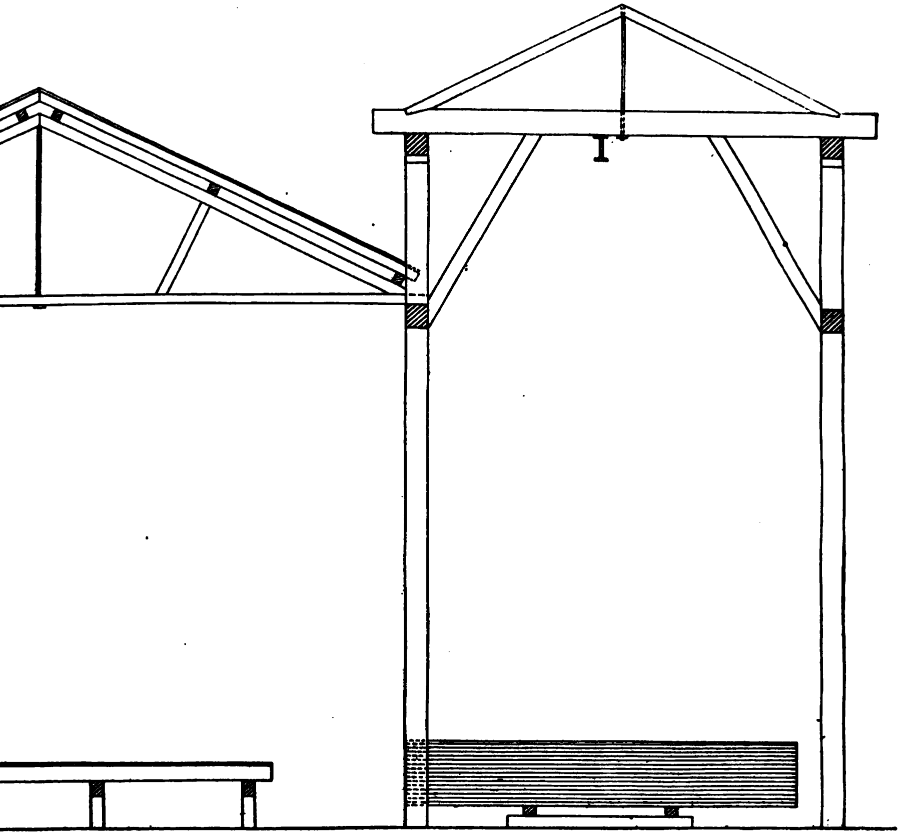


Fig. 36. End elevation of

Superstructure:		
79,802 ft. of lumber @ $9.00 per 1,000 board feet	718.22	
Framing @ $3.207 per 1,000 board feet	255.94	
Raising @ $3.493 per 1,000 board feet	278.72	
Incidentals @ $0.031 per 1,000 board feet	2.50	
Iron (bolts, spikes, drifts, etc.) @ $5.832 per 1,000 board feet	465.38	1.720.76
Dock (exclusive of foundation):		
62,101 ft. of lumber @ $6.427 per 1,000 feet	399.11	
Labor @ $3.122 per 1,000 feet	193.86	
Iron @ $0.556 per 1,000 feet	34.54	627.51
Crane proper:		
Contract price	$3,000.00	
Freight	1,152.18	
Assembling @ 5.94 per cent of contract	178.12	
Expense @ 0.46 per cent of contract	13.84	$4,344.14
Electrical installation:		
Supplies	188.38	
Labor	23.69	212.07
Painting (400 squares):		
Material @ $0.477 per square	190.97	
Labor @ $0.23 per square	91.88	282.85
Rails	222.85	222.85
Total cost of work		$8,811.66
Less the cost of dock		868.96
Cost of crane and structure proper		$7,942.70



...rting table and monorail.

PERCENTAGE COSTS OF OVERHEAD CRANE AND DOCK UNDER IT (1916)

Timber Crane ($7,942.70)

			Cost	Per cent
Engineering and supervision			$ 118.70	1.48
Substructure:				
Piling	$ 83.80	1.057		
Caps	73.15	.922		
Expense	54.85	.692		
Drift bolts	6.72	.086		
Labor	264.38	3.329	482.90	6.08
Concrete piers:				
Forms:				
Lumber	15.98	.202		
Nails	3.22	.041		
Labor	31.91	.403	51.11	.64
Concrete:				
Cement	136.92	1.724		
Sand	35.00	.442		
Gravel	67.00	.845		
Expense	.84	.002		
Labor	235.72	2.969	475.48	5.99
Bracing substructure:				
Lumber	24.19	.305		
Labor	7.65	.097	31.84	.50
Superstructure:				
Lumber	718.22	9.043		
Framing	255.94	3.223		
Raising	278.72	3.510		
Incidentals	2.50	.032		
Iron	465.38	5.860	1,720.76	21.66
Crane machinery:				
Contract	3,000.00	37.772		
Freight	1,152.18	14.506		
Labor assembling	178.12	2.244		
Expense assembling	13.84	.174	4,344.14	54.70
Electrical installation:				
Supplies	188.38	2.372		
Labor	23.69	.298	212.07	2.67
Painting:				
Material	$ 190.97	2.405		
Labor	91.88	1.156	282.85	3.56
Rails:				
Material	222.85	2.806	222.85	2.81

Dock ($868.96)

Substructure:				
Piling	41.90	4.823		
Caps	36.58	4.211		
Expense	27.42	3.156		
Drift bolts	3.36	.386		
Labor	132.19	15.212	241.45	27.78
Superstructure:				
Lumber	399.11	45.929		
Labor	193.86	22.308		
Iron	34.54	3.975	627.50	72.22

CAPACITY OF OVERHEAD CRANES

The capacity of overhead cranes is not well established because there are not enough in use yet to obtain reliable averages and each has such a peculiar kind of work that the capacities are not comparable. As an example of what may be expected under extremely favorable conditions in regard to size and accessibility of timbers, 12-16 M. ft. B. M., a car of timbers was loaded with the crane shown in the frontispiece in exactly 52 minutes by a crew of three men, at a labor cost of about two cents per thousand. The crane had not been in operation a month.

LOCOMOTIVE CRANES

Locomotive cranes (Fig. 39) are used at some of the cargo mills for conveying lumber from the mill to the dock and handling it there. They are also used for conveying lumber to the yard and lifting the units upon piles for loading lumber and timbers upon flat cars, and for other handling work; and they serve for special work, such as dredging, log handling, car moving, and other similar duties.

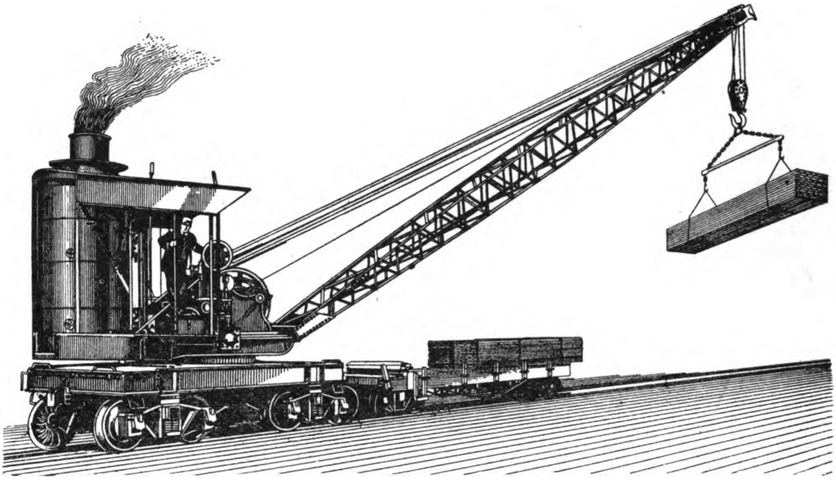


Fig. 39. 8-wheel locomotive crane and storage car.

The cranes are usually of the eight wheel or double truck type. A few of the four wheel machines are in use, but they are said to be less stable and slower in operation than the others because of the poor character of the track upon which they are usually run. The length of the boom stick usually varies from 40 to 50 feet. The draw bar pull is from 7,500 pounds to 10,500 pounds.

The cranes usually have a speed of about six miles per hour. The fuel consumption per day is about one barrel of oil, one-third of a cord of wood, (cut to 16-inch lengths) or one-fifth of a ton of average Pacific Coast coal.

The 10-ton, 4-wheel cranes cost from $9,000 to $10,000 (1916) delivered on the Coast, and the 8-wheel type about $1,000 more. The 20-ton size with eight wheels is $12,000.

OPERATIVES AND THEIR DUTIES

The crane is usually in charge of an engineman, who controls all its movements and is ordinarily assisted by a fireman. A hook tender accompanies the crane to adjust the slings or other equipment used for holding the load.

DRY KILNS (1916)

Practically all Douglas fir lumber manufacturing plants are equipped with dry kilns, with the exception of a few cargo mills, the tie cutting plants, and the small portable and custom mills

Lumber is kiln dried to reduce its weight and to retard its tendency to check and warp when put to use. Kiln drying also dries up the pitch and prevents or retards its exudation through paints, enamels, and similar coverings applied to the finished product.

TYPES OF KILNS

There are three types of kilns in general use in the Douglas fir region; i. e., standard kilns relying on natural circulation, and natural draughts, kilns equipped with special pipes to create circulation, and blower type kilns, in which fans are employed to insure rapid circulation. The number in use is in the order mentioned. Kilns are further divided into high temperature and low temperature groups and into those using outside draughts and those using no outside air. The kilns using no outside air are being used quite extensively now, though not so much as their success appears to warrant.

Douglas fir is easily dried and can be successfully seasoned without specially equipped kilns, although their use may tend to make the operation more easy to control and therefore more uniform. The cost of especially equipped kilns is usually higher, and most of them require more expert supervision than those of standard construction.

CAPACITY OF KILNS

The volume of lumber which can be dried in a given period varies with so many factors that it is impossible to give definite figures for kilns of a given size. The following table will serve as a guide to kiln capacity where the length of the drying period is known.

CAPACITIES OF KILNS PER SQUARE FOOT, INSIDE MEASURE

Drying period, hours	Board feet of 1-inch lumber dried daily High	Medium	Low
24	40	30	25
36	26.6	20	16.6
48	20	15	12.5
60	16.6	12.5	10
72	13.3	10	8.3

Note. The variation is due principally to thickness of stickers and similar factors affecting the quantity of lumber per square foot of kiln.

KILN BUILDINGS

The dry kiln buildings ordinarily consist of a single chamber or battery of chambers 10 or 20 feet wide and from 50 to 120 feet long. They are equipped with tracks upon which the kiln cars move through the drying chambers, the wide kilns having two tracks and the narrow kilns one. Below the tracks is a pit from three to six feet deep to provide for the heating pipes and easy movement of air below the cars. The ceilings are from 11 to 12 feet above the rails.

The foundations and floors are usually of concrete (3 inches thick) and the roof of laminated wood construction (2 inches x 6 inches), although arched tile and concrete roofs have been successfully used to make the kilns fire resistant. The walls are made of hollow tile, brick or concrete, usually about 12 inches thick, reinforced by pilasters.

There is little difference in the average cost of brick or concrete kilns, although local conditions may make one considerably cheaper than the other. The following tabulation will serve as a guide in estimating the complete cost of typical kiln buildings, including doors, foundations, floors, and roofs, but no piping, track, or other equipment, since these are covered elsewhere.

COST OF KILN BUILDINGS (1916)

Item	High	Medium	Low
Foundations and floors, per square foot	$ 0.12	$ 0.10	$ 0.08
Walls, per square foot	.25	.20	.15
Roof, per square foot	.25	.15	.12
Roof covering, per square foot	.05	.04	.03
Slatted asbestos doors (9x12 ft. each).	22.00	20.00	18.00
Door track, per linear foot	1.35	1.25	1.15
Door carriers, each	50.00	40.00	30.00

TRACKS, TRACK SUPPORTS, AND PIPING

Kiln tracks are usually of thirty-five pound railroad steel, costing from $40 to $50 per ton delivered at Pacific Coast terminals. This makes the tracks cost about 25 cents per foot per rail. The rails are spaced about six feet apart, and at a slope of 1/40 to facilitate movement of the cars through the kilns.

The track supports vary in height from three to six feet, depending on the depth of the pit. It used to be the practice to provide the slope to the track by varying the height of the supports, but now the floor of the pits is sloped at the same angle as the track and the supports are of uniform height.

By attaching horizontal cross pieces to the upright supports provision is made for suspending the pipes.

The standard pipe for kilns is one inch in inside diameter. It is usually made of wrought iron and costs from $5 to $8 per 100 feet delivered at Pacific Coast terminals (1916). The average amount of pipe is about one-half of a linear foot to each cubic foot of kiln, inside measure above the rails.

The pipes are easily drained, since they take the same slope as the track and are carried on the same supports, Fig. 40.

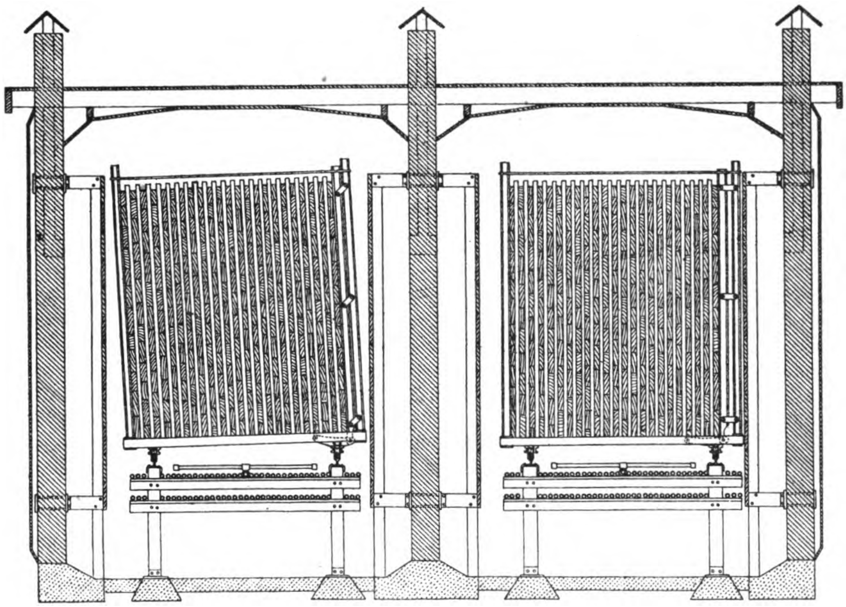


Fig. 40. Sectional view of two-chamber dry kiln with vertical stacked kiln cars, showing how take-up stakes absorb slack due to shrinkage and keep load tight and boards flat.

For standard kilns there is little or no difference in the cost of the equipment installed, such as tracks, track supports, and steam pipes and their

supports. The figure commonly used in estimating the cost of this portion of fir kilns is from $.90 to $1.00 per square foot of kiln, inside measurement. This does not include tracks outside the kiln, nor steam mains and hot water pipes between the kilns and power plant; it does not include the usual installation of perforated pipes for giving the lumber a preliminary steaming. This part of the equipment weighs about 5 pounds per square foot of kiln.

THERMOMETERS

It is essential that each unit of a battery of kilns be equipped with a recording thermometer. One thermometer for a series of kiln chambers is not sufficient, since the temperatures are seldom the same in all the chambers, nor do they vary a constant amount. The thermometer is placed far enough from the door to eliminate the cooling effect of cracks, and well away from cold air ducts and other disturbing elements.

Recording thermometers can be purchased at from $40 to $50 each (1916) (16 foot extension).

GAUGES, REDUCTION VALVES, AND STEAM TRAPS

Steam gauges, reduction valves, and steam traps are necessary to successful kiln operations. There is usually a separate gauge and reduction valve for each unit of a battery of kilns. These are for use in controlling and maintaining a proper drying temperature. Steam traps are very effective in ejecting, automatically and without unnecessary loss of steam, the water which constantly condenses in the pipes.

AUTOMATIC TEMPERATURE REGULATORS

Even where gauges, reduction valves, and traps are used, it is difficult to maintain a constant temperature in dry kilns; for a drop or increase must be indicated on the recording thermometers before the operator is aware of the conditions in the kiln, and it usually takes some time before the temperature can be brought back to normal. A regulating device which controls the temperature automatically and within one degree at all times has recently (1916) been placed on the market. It costs approximately $120 per kiln, exclusive of compressed air equipment.

THE DRYING PROCESS (1916)

PRELIMINARY TREATMENT

Many kilns for drying Douglas fir are equipped with perforated pipes by means of which the boards in the drying chamber may be given a steam bath before the drying process is begun. The need for this preliminary treatment depends upon the condition of the lumber when it reaches the kiln (whether it is surface dried) and the rapidity with which the drying operation is to be conducted. Successful drying requires that the moisture be evaporated from the surface of the board at no faster rate than it is conducted from the interior to the surface. If it dries too rapidly on the surface, warping, checking, and casehardening may result; and if it dries too slowly, the kilns are not being operated at their full capacity. Since the rapidity with which the moisture is drawn from the interior by capillary action is in proportion to the temperature of the wood, the wood should be well heated before the drying is started, unless it is to be dried at a very slow rate. Preliminary steaming not only heats the wood and prepares it for drying, but moistens the surface and retards or prevents drying until the wood is in condition to dry without injury.

TEMPERATURE

Sufficient heat constantly maintained is the most important element of efficient kiln drying. If the boards are given a proper preliminary steam bath and the humidity in the kiln is kept reasonably high (by the exclusion

of draughts or otherwise) during the early stages of the drying process, the temperature may be maintained well above the boiling point of water (212° F.) without injury to the wood (Douglas fir) for most purposes and the maximum capacity of the kilns can be reached. The only danger is that the lumber may be dried too much by being left in the kiln too long under excessive heat or by the humidity's being allowed to fall too soon. Temperatures above 230° F. are not advisable unless special equipment is employed to insure the maintenance of proper humidity at all times.

High temperatures decompose the pitch and prevent it from exuding after the boards are put to use.

It is important that uniform temperatures be maintained both day and night, since any reduction in temperature causes the suspended moisture to be deposited on the lumber, so that it must again be evaporated before the drying can continue. Heat from exhaust steam is seldom uniform or sufficient for keeping up the temperature properly. Temperature regulating devices are desirable, for they insure sufficient heat to prevent condensation or other hindrances to efficient work.

HEATING THE LUMBER

It is essential that the heat be transmitted from the pipes to the individual boards as rapidly as possible. Heat is transmitted through air by radiation, convection, and conduction. Any factors in the construction or operation of the kiln which accelerate the flow of heat in any of these three ways aid the drying operation. Conversely, any interference with such means retards drying.

Radiated heat is transmitted only in a straight line, either directly or by reflection. Radiation is the most active force in liberating heat from the steam pipes to the air. Its activity is controlled chiefly by differences in temperature between the pipe and the surrounding air, and therefore it is best to separate and "stagger" the pipes (Fig. 40) in such a way that the heat from one pipe will reduce the radiation from its neighbor as little as possible. Straight vertical openings through each car of lumber greatly assist radiation in transmitting the heat to the load.

Convection is next in importance. By it the warm air, which is expanded by the heat radiated from the coils, rises through the load. Here again straight vertical openings greatly assist the flow of heat.

Conduction ordinarily plays a minor part, since air is a poor conductor of heat; but when flat piling is employed, some heat does reach the boards by being conducted horizontally through the air spaces between the boards.

Circulation may be accelerated in several ways; but regardless of the method, it is essential that the heat be distributed through the load as uniformly as possible in order that both sides of the boards may dry at the same rate (to avoid warping) and that all of them may be equally dry when the load is removed from the kiln.

False walls, cooling pipes, sprays, and other means of creating differences in temperature to induce convection (circulation) all assist in the drying operation; but if the heating pipes are properly arranged and high temperatures and vertical stacking are used, false walls are about all that is necessary to insure good circulation. The normal movement of the air is up through the load and down the sides (Fig. 40). Heating pipes should be placed only beneath the load. If they are placed to either side, they prevent downward circulation at the sides and thus retard drying.

DRAUGHTS

Many of the older kilns and some of the new ones are built with air ducts and ventilators to encourage a constant passage of air through the loads of lumber, to assist in drying, and to carry the moisture from the kilns. These are necessary where low temperatures are used, since under such conditions

lumber will not dry properly in stagnant air. They make control of humidity difficult, however; and unless there is special equipment for the regulation of humidity, or the kilns are operated at very low temperatures, warping and checking are difficult to avoid.

If temperatures near or above the boiling point are used, draughts are not needed, since the extreme heat causes the water to evaporate without the exchange of air and the water vapors are forced from the kiln by the pressure created. High temperature kilns should be constructed so that draughts through the kiln are impossible, although vents for the discharge of surplus moisture may be employed. The actual need for such vents has not yet been proved, for Douglas fir kilns are being operated successfully with the cracks around the doors as the only means of escape for the surplus moisture.

HUMIDITY

In the operation of low temperature kilns equipped with air ducts and ventilators to create draughts, the relative humidity (ratio of the amount of moisture the air contains to the maximum amount it could contain at its temperature) of the air passing through the loads of lumber is the paramount drying factor, since the air acts as an absorbent of the moisture as well as the vehicle by which it is removed from the kiln. Cold outside air, humidity about 70 per cent, is conveyed (by means of natural draught) up through the heating pipes, where its humidity is reduced to about 15 per cent. Through proper arrangement of the ventilators, this dry, absorbent air is passed through the loads of lumber, striking the driest loads first, gathering moisture from the boards and conveying it to the outside air. The process is extremely delicate, however, owing to the difficulty of regulating the speed with which the air passes through the kilns. It is obvious that every gust of wind will change the velocity and may bring very dry air in contact with some of the green lumber, so as to cause excessive surface drying.

TIME REQUIRED FOR KILN DRYING DOUGLAS FIR

When properly kilned, Douglas fir lumber contains from five to eight per cent of moisture (i. e., the kiln dry boards weigh only from 5 to 8 per cent more than they would weigh if they contained no moisture at all). If dried below this moisture content, the boards become brittle and the expense of the excessive drying is largely wasted; if the lumber is exposed to the air (especially during the winter months) it will absorb to 6 or 10 per cent moisture.

It is important when dry kilns are first installed, and subsequently as occasion demands, that a series of tests be made to ascertain how long lumber of given size and condition must be left in the kilns to reach the proper degree of dryness. If such determinations are not made and the time is based entirely on estimates, the lumber is likely to leave the kiln either too dry or too wet; for it is very difficult to build kilns sufficiently alike to insure the same degree of humidity and temperature under apparently identical conditions.

Test pieces should be placed in at least one load of each charge until the experiments indicate that uniform results are being obtained and that further study is unnecessary. The tests can be made in the same manner as those to determine the moisture content of air dried material. (See subsequent paragraph).

The time required to kiln dry Douglas fir depends upon the amount of circulation, the temperatures used, and the humidity of the surrounding air. The preliminary steaming should not require more than 4 or 5 hours, if the sprays are sufficiently large to keep the kilns well filled with steam during the treatment. One inch stock can be heated through in this time. As for the actual drying, under normal conditions with temperatures at or above the

boiling point the heartwood of Douglas fir should lose from 1 to 1¼ per cent of moisture per hour, until it is dried down to eight or nine per cent, there being about 25 per cent of the total weight of green wood due to the moisture. At this point the rate of drying falls off rapidly and the additional time required to evaporate further moisture is not warranted. Thus typical heartwood boards of one inch stock can be kilned properly in 24 hours, including the time used in preliminary steaming. Sapwood boards one inch thick can be dried in almost as short a time, since the free moisture in the wood cells of sap boards can be evaporated at the rate of from 30 to 35 per cent per hour.

HEAT REQUIRED FOR KILN DRYING

It is well to make temperature tests simultaneously with the time tests. These will give an idea of the distribution of heat through the loads and show the relation between the temperatures indicated on the recording kiln thermometer and those actually found in the loads. The tests can be made with either maximum or recording thermometers. The recording thermometers are preferable because they give a complete record.

About 800,000 British thermal units are required to properly kiln dry one thousand board feet of Douglas fir when the kiln temperature is 212° F. Five million B. t. u. are needed to dry the same amount of sap lumber, because of its excessive moisture; but the percentage of sap in most Douglas fir kiln stock is so small that for practical purposes the heartwood only may be used as a basis in thermal calculations.

Since the heat for dry kilns is ordinarily supplied by the steam boilers used for general power purposes, the power for kilning must be computed in terms of boiler horsepower. One boiler horsepower is equivalent to the heat necessary to evaporate 34.5 pounds of water from water at 212° F. into steam at 212° F., or 33,479 B. t. u., per hour. Thus, if the lumber is to be dried in twenty-four hours, 33,333 B. t. u. (one twenty-fourth of 800,000 units), or approximately one boiler horsepower, is required for each one thousand board feet of lumber in the kilns. This is the net power requirement, and since considerable heat is always lost through radiation from the mains, kilns, and kiln doors, as well as through vents and cracks, it is best to figure on from 50 to 100 per cent more.

LOADING KILN LUMBER

ARRANGEMENT OF STOCK

Both the flat method and the edge method of loading are in use in kilns in the fir region. The former is more common, but the latter (Fig. 40) is more efficient and is rapidly displacing the other in the most progressive operations. The lengths may or may not be separated in either method; but where the lumber is piled flat the widths should be separated, if possible, since it is difficult to pile mixed widths flat and insure uniform distribution of heat through the loads. Owing to the difference in time required for drying, thicknesses are kept separate in both methods.

The courses of boards are separated by strips called stickers, which vary in width from one to four inches. One inch and two inches are most common. The thickness is nearly always one inch or slight variations from it to suit the stock available for the purpose, or to insure strength where it is required. The stickers are usually made as narrow as possible without being unduly weak, since drying is always retarded where they come in contact with the boards. Four inch flooring strips are sometimes used as stickers; but the strips do not dry properly and when sold with other strips decrease the "under weights" and in other ways make unsatisfactory stock.

Flat piled loads of one inch boards are usually made 50 courses high for kilns of ordinary height, while vertical loads are from 42 to 51 courses wide, depending upon the thickness of the stickers.

If the lengths are to be mixed, it is advisable to make the loads as long as the longest pieces, so that none of the pieces will protrude from the ends of the load and become broken, warped, or over dried. The short pieces can be doubled up and those of medium length can be placed flush at alternate ends to make the load of even length throughout.

OPERATIVES AND THEIR DUTIES

The practice of piling lumber upon kiln cars by hand is rapidly becoming obsolete, but a good deal of the lumber is still piled in this way. The men usually do the piling in pairs. One man stands on the ground and hands the boards to the other, who is up on the load. Sometimes the material is placed on the kiln cars at the sorting chains, so that one handling is saved. This is not feasible under most conditions, since there is seldom sufficient lumber of one width constantly available on the sorting chains to keep a piling crew busy.

Two men can load from 2,500 to 4,500 feet of lumber per hour upon kiln trucks, depending on the size of the boards, the size of the cars, and the accessibility of the lumber. The best speed can probably be made if the boards to be loaded are stationed at the end of the car and at a height of about six or eightt feet above the trucks, for then most of the boards can be loaded by one man working alone and pulling the lumber down upon the car.

Where piling is done by machine, as in Fig. 41, two men are often used, one operating the machine and the other arranging the lumber on the conveying chain. Under favorable conditions, however, the machine can be operated by one man. When the lumber stacker is placed at the end of or along side the sorting chains or the boards for the kiln are conveyed to the stacker on chains instead of trucks or other carriers, one man can easily operate either of the machines; otherwise two are necessary to keep the machines in constant operation. The machines handle from six to ten thousand feet of lumber per hour.

LABOR COSTS (1915)

Hand piling costs from 15 to 25 cents per thousand board feet, depending on the thickness and length of the material, the size of the loads, the accessibility of the boards, the method of pay, and the percentage of time the men are actually engaged in the work. This includes handling the stickers and car parts. Contracts now in effect provide for from 16 to 20 cents per thousand board feet.

Costs of loading kiln cars by machine vary from 7 to 18 cents per thousand feet, depending on the number of men used on each machine, the size of the kiln stock, and the time lost in waiting for lumber. Contracts call for 11 cents per thousand feet for one inch lumber and 9 cents for two inch. The men are required to handle the car parts and stickers necessary for their work.

UNLOADING AND SORTING KILN LUMBER

Since the unloading and sorting are usually done by the same crew, it seems proper to treat them as one operation. At a few plants the lumber is carefully sorted before it goes to the kiln. It is unloaded from the kiln cars by the operator feeding the planing mill machine, and graded and handled behind the machine. This is not practicable when fast feed machines are used; neither is the grading in the green entirely satisfactory, because of difficulty in detecting and anticipating defects.

When kiln cars are unloaded by hand, the men usually work in crews of two. One stands on top of the load and hands the boards to the other, who stands on the ground and grades or sorts the boards, placing those of different size and quality on separate trucks. The man on the ground is the more skilled, and has a knowledge of the grades of the rough boards and the product they are best suited for.

Unloading by hand is necessary where the loads are flat piled and in small plants where there is not sufficient kiln stock handled to justify the installation of a machine. Two men can unload and sort from 20,000 to 40,000 feet per day.

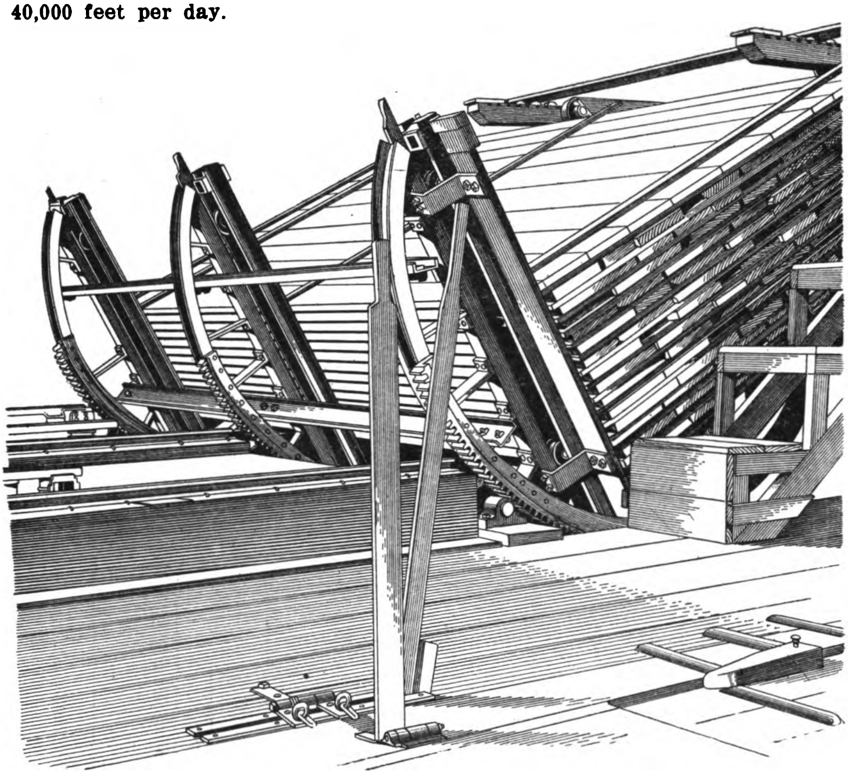


Fig. 41. Tilted car type of lumber stacker.

The cost of unloading and sorting by hand varies from 20 to 40 cents, depending upon the average size of the stock and the amount of sorting done. One contract in effect where the work is fairly representative calls for 25 cents per 1,000, including emptying the kilns and careful sorting. Another contract, for unloading without sorting, is for 12½ cents per 1,000.

Unloading machines like the one shown in Fig. 42 are very efficient and are used wherever the amount handled warrants. The actual unloading can be done by one man, but it usually requires two or more to sort the stock, depending upon the speed at which the machine is operated and the number of segregations employed, i. e., the length of the sorter. From 100,000 to 150,000 feet can be unloaded daily with one of these machines.

The sorting is done on tables similar to the green lumber sorting table, only smaller and operated with fewer men.

The cost of unloading and sorting by machine varies from 15 to 30 cents. The unloading runs from 3 to 10 cents per 1,000 and the rest is for grading and sorting. The machine work could be made much cheaper than the hand work if there was less sorting; but at all plants where machines are employed the lumber is carefully sorted for use in the manufacture of products for which it is best adapted. This extra expense in handling is well justified by the better utilization of the lumber.

LUMBER STACKING MACHINES

Two types of machines for mechanically loading lumber upon kiln cars have come into considerable use in the fir region. Both of these stackers are designed to place the lumber in a vertical position (on edge) for the drying process.

At the present date the lifting-arm stacker has gone out of use, particu-

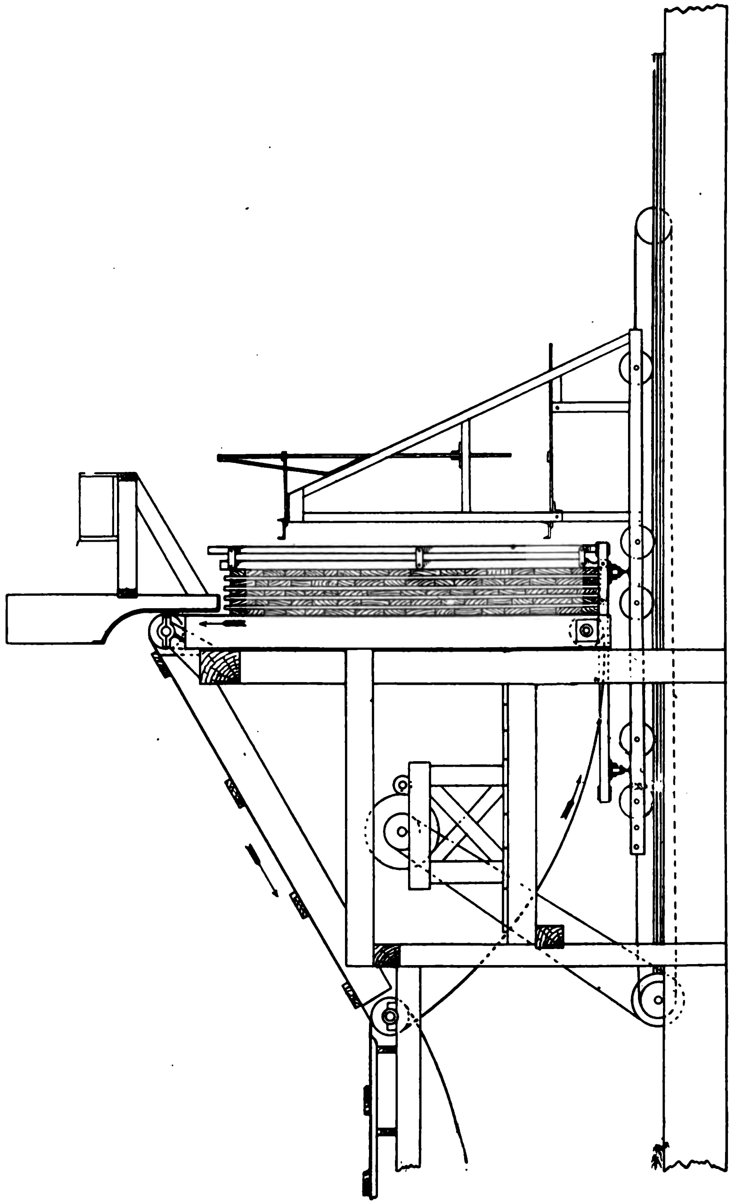


Fig. 42. Vertical type of unstacker.

larly in new installations, and in some cases is being replaced by the tilted-car type. (Fig. 41.)

The lumber fed into them is sorted by thickness, but may or may not be sorted by widths and lengths. It may be delivered to the machine in units, or on ordinary transfer chains. Delivery on transfer chains is often preferable, because it may permit successful operation of the machine by one man.

TILTED CAR STACKER

Kiln cars to be loaded with the tilted-car stacker are tilted to an angle of about 45°, as shown in Fig. 41, by means of a rack and pinion cradle. The lumber is slid into the stacker from the ends of skids equipped with slow moving chains. The skids are hinged so as to permit raising and lowering as the height demanded in loading requires. The chain is operated by friction drive controlled by the operative.

Tilted-car stackers are built in three sizes. The three arm size, which is the smallest, will accommodate lumber from 8 to 18 feet in length; the five arm stacker, which is the largest, will take lumber from 8 to 24 feet in length. The largest size is best suited to most Douglas fir operations, since considerable lumber is cut in lengths greater than 18 feet.

The three arm stackers cost about $950, the four arm $1,200, and the five arm $1,450 installed (1916).They weigh 7,000, 8,000, and 12,000 pounds respectively. These costs do not include the sorting chains and drive.

The power for this kind of stacker is usually furnished by a five horse-power motor which, according to the following power data, is ample:

Average input during day..........................	2.25 Kw.
Maximum instantaneous input..........................	5.10 Kw.
Maximum sustained input..........................	2.8 Kw.
Friction of transmission..........................	1.4 Kw.

The average power consumed per thousand board feet of lumber is 0.48 Kw. Hrs.

LIFTING-ARM STACKER

A lifting-arm stacker is fed in the same manner as the tilted-car stacker, but the car remains in a normal position and each tier of boards is raised to a vertical position by a series of arms and the stickers held against by triggers. The machines are built in the same sizes as the others and the cost is approximately the same.

A three or five horse power motor is large enough for a stacker of this kind, since the only work directly chargeable to actual stacking is that required in lifting the arms and a layer of boards from an oblique to a vertical position and bringing the truck forward a distance equal to the thickness of the stock and sticker. Tests show that about 4.3 Kw. are needed for such work. The motors for stackers of this class are also frequently connected in such a way that they can be made to run the conveying chains as well.

LUMBER UNSTACKING MACHINES

There are two types of machines for unstacking dry kiln cars. They are alike in size (3, 4, or 5 arms) and both deposit the lumber upon ordinary sorting chains, where it can be graded and segregated easily.

VERTICAL UNSTACKER

The vertical unstacker, so called because the lumber is removed from the machine in a vertical direction, is the older type and has been in successful operation for a number of years. It moves the boards from their position in the load by means of an endless chain equipped with lugs or brackets which catch beneath the edge of the bottom boards of each tier consecutively and force the layer of boards up along and over the upright parts of the machine, from where they slide down slanting skids to the sorting chains.

A five horse power motor should be sufficiently large for these unstackers, since tests show that the average demand for unloading is only 3.2 Kw., and the maximum 3.9 Kw.

The vertical unstacking machines cost (1916) $750, $850, and $950, respectively, for use with the 3 arm, 4 arm, and 5 arm stackers. These are installed prices exclusive of motor.

HORIZONTAL UNSTACKER

The horizontal unstacker removes the lumber from the cars after they have been placed in a horizontal position in a cradle operated by a motor-driven rack and pinion. An endless chain slides the individual layers upon a sorting chain, which is made adjustable at the end near the car so that it can be lowered as the car is unloaded.

No power data are avaliable for this unstacker, but the company making them recommends a 6 h. p. motor. The larger motor is necessary because of the temporary heavy demand in tilting the car to a horizontal position.

KILN CARS

CARS FOR EDGE-STACKED LUMBER

Typical kiln cars are composed of three essential parts—trucks, bunks, and stakes. Each bunk is ordinarily equipped with two trucks and two stakes. The cars shown in Fig. 40 are equipped with the take-up stake, which automatically prevents warping by tightening the load as shrinkage takes place. Such cars are ordinarily used with lumber eight inches or over in width and may be used to advantage with all widths, since they tend to keep the loads tight and prevent them from falling apart in the kilns.

For charge kilns, it is usually good practice to figure on sufficient cars to fill the kilns twice. For progressive kilns, fifty per cent more than the capacity of the kilns is ample.

The cost of each standard set of car parts for vertical stacked loads is as follows (1916):

2 18 inch trucks, 8 inch wheels @ $3.50 each	$7.00
1 8 foot bunk	5.75
2 11 foot stakes @ $2.90 each	5.80
1 binder	1.15
	$19.70
Extra for "take-up" stake	$6.00

The number of sets required for each kiln car is as follows:

For lumber from 6 feet to 12 feet long	2 sets
For lumber from 14 feet to 22 feet long	3 sets
For lumber from 24 feet to 32 feet long	4 sets

CARS FOR FLAT-PILED LUMBER

A typical car for flat piled lumber consists of a series of bolsters or bunks supported at either end by a short two wheeled truck similar to those used for edge stacked lumber. From three to five of these sets of bunks and trucks are used to a load, depending on the length of the lumber. The bunks are usually of wood, about 8 inches x 8 inches in cross-section and from 8 to 9 feet long. They are spaced so that they come directly beneath each of the stickers.

The trucks cost $3.50 each or $7.00 per set, and the bunks cost $0.50 each (1916). Steel bunks which cost $5.50 are sometimes used.

COST OF KILN SUPPLIES AND REPAIRS

Kiln supply costs include lumber used for stickers, oils for stacking and unstacking machines, ink and charts for recording thermometers, and the

like. The stickers are the principal item of expense, and their cost varies with their size and the spacing employed, being from one to three cents per thousand feet of lumber dried. One or two cents is ample for the majority of cases. The cost of the other supplies seldom exceeds a fraction of a cent per 1,000 feet of lumber dried.

Information obtained at a large number of plants indicates that kiln repair costs for labor and materials range from two or three cents to fifteen or twenty cents per thousand feet of lumber dried. In the majority of cases they were between five and ten cents per thousand; and it is believed that well constructed kilns can be kept in good condition on the basis of the lower figure.

STORAGE TRACKS AND SHEDS FOR LOADED CARS

A plan for kiln storage tracks and cooling sheds is given in Figs. 2 and 38.

TRACKS

The storage tracks in front of and at the rear of the kiln are usually made long enough to take from one car to as many cars as the kiln will hold, depending upon the method of charging and discharging the kilns. The gauge of the track is commonly 6 feet, and the rails are of 30 or 35 pound steel. The distance between the two inside rails of a double tracked kiln is 3 feet-6 inches; and the distance from the outside rail of one kiln compartment to the outside rail of the next one to it is 5 feet-2 inches. These distances give ample room for men to go between the cars.

The tracks cost about 30 cents per running foot of rail, installed.

COOLING SHEDS

At the rear of the kilns the tracks are usually covered by sheds to keep the material dry while it is being cooled and waiting to be unloaded. These sheds cost from ten to twelve cents per square foot (of ground covered) above the platforms, including lumber, roofing, hardware, and all labor. In one shed there are 3½ board feet of lumber per square foot of shed.

TRANSFER CARS

A typical transfer car is shown in Fig. 43. It is operated by endless cables running along the transfer track, one strand moving in one direction and the other in the opposite direction. The kiln cars are pulled on or off the transfer car by means of blocks and an extra drum acting as a windlass and driven by the same cable which operates the transfer car. Such a transfer car costs about $150 (1916), exclusive of cable and drive, and weighs between 1,600 and 1,700 pounds.

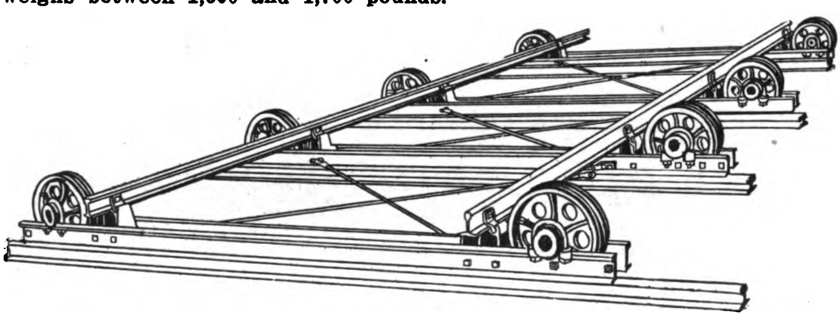


Fig. 43. Four track transfer car for switching kiln cars.

SORTING TABLE FOR KILN-DRIED LUMBER

As the kiln dried boards come from the unloading machines they are run out upon a sorting table, and are segregated into sizes and grades for the

dry storage sheds or the planing machines. This table is from 16 to 20 feet wide, has from 4 to 6 chains, and is from 75 to 200 feet long, depending upon the number of segregations provided for and whether the layout permits sorting on one or both sides of the table. The chains and drive are usually lighter than those of the green sorters, but the method of construction is similar.

Where kiln car unloading is done by hand, sorting tables are not used and the sorting is done by the unloading crew, the pieces being placed directly upon trucks.

The general layout of the table and shed is shown in Fig. 2. Usually the shed is smaller and less elaborate than that shown, but it is always of sufficient size to keep the stock protected from the weather.

The sorting is in charge of a marker or grader, who determines the use to which each piece can best be put; that is, whether it should be run to flooring, drop siding, ceiling, or what not. He is assisted by a sufficient number of sorters to segregate the stock properly into units for the monorail, crane, or auto trucks.

Sometimes a rip saw is placed beside the sorting chains, and boards which must be ripped to improve the grade are diverted to the rip saw and returned to the chains for regrading after cutting.

The cost data given previously for transfer tables and their drives are applicable to these tables, and the shed costs can be estimated from the data given for the green sorting sheds. The speed of the chains and the power requirements are like those for other sorters.

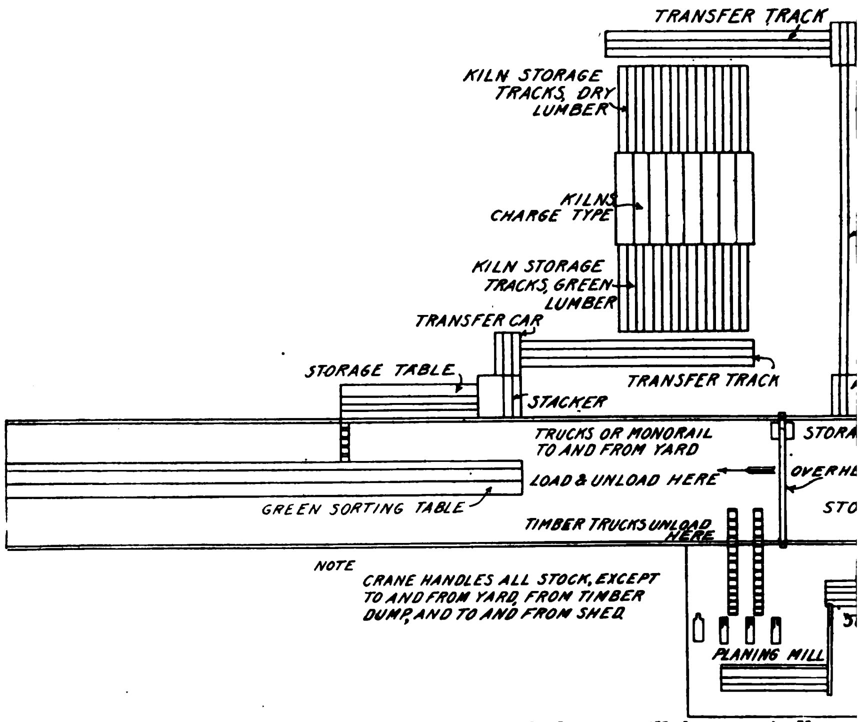


Fig. 38. Layout of planing mill for practically co

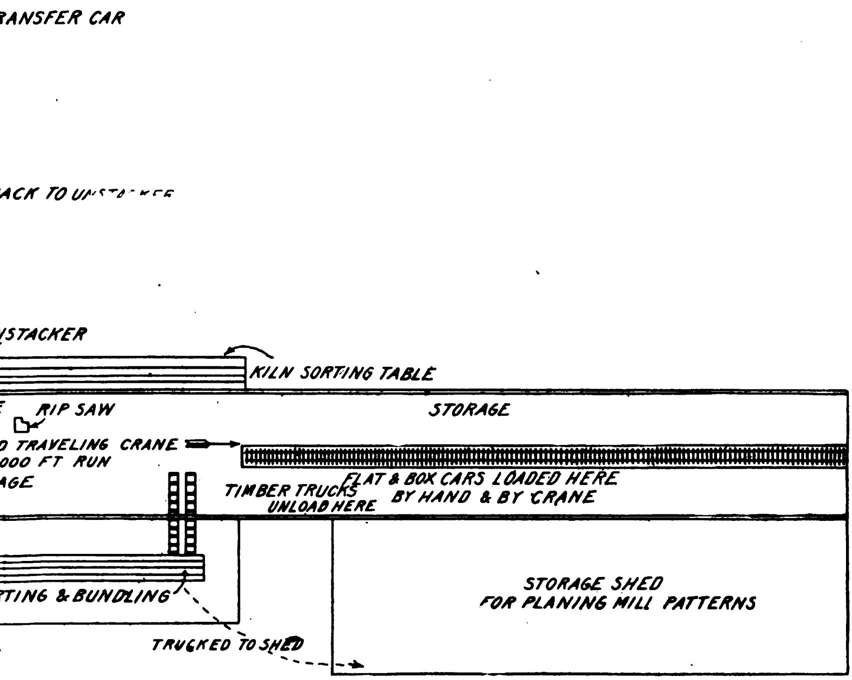
AIR SEASONING AND STORAGE

The purpose of air seasoning lumber before shipment is primarily to effect a saving in freight by evaporating the surplus moisture and decreasing the weight. Seasoning also prevents shrinkage and warping when the lumber is put to use. Furthermore, many buyers prefer air dry lumber because green boards have a tendency to depreciate in grade during the seasoning operation and they do not care to stand this loss in value. Storage yards are necessary as a place to pile properly that portion of the cut for which there is no immediate demand.

YARDS

The main gangways of a lumber yard (Figs. 2 and 44) are usually 24 feet wide, and the side gangways 20 feet. The space between the rear ends of the piles is from 4 to 12 feet. Twelve feet allows room for lumber of unusual length without blocking the movement of air between the rows of piles. A wide space is advisable where at all possible. The space between the sides of the piles is ordinarily from 2 to 3 feet, 2 feet being most common.

An ideal yard layout provides foundations for two or more piles of each size and class of material. When this is not possible, different lengths of the same thickness, width, and grade are placed in the same pile. There is little or no uniformity among fir operators as to the grouping of the piles. Some group piles contain the same length in one gangway; others group their piles by grades; and still others by thickness, keeping the piles containing material of the same size and grade as close together as possible. Of these various methods, the length scheme seems least desirable because it necessitates going to a large number of gangways to get material for the



plete handling by one overhead travelling crane.

usual run of orders; and unless full trucks of each length are required, the trucks must be moved around considerably to assemble the shipment, or sorting must be done at the car.

PILES

The height of the piles in Douglas fir yards seldom exceeds 18 or 20 feet (50 courses of 2 inch and 100 courses of 1 inch) unless the piling is done by machine (Fig. 44). The slope of the boards (from the horizontal) is usually 1 to 24 and the pitch of the pile (from the vertical) is 1 to 12. The first angle is to make the boards and pile shed water, and the second is to prevent rain from getting into the pile and running down the boards.

The horizontal space between the boards is usually one-half the width of the piece but seldom exceeds 3 inches when the widths are piled separately. The vertical spacing is either 1 inch or 2 inches, pieces of the regular stock being usually used for cross sticks, except when the stock is thicker than 3 inches and longer than 20 feet, in which case strips 1x3 or 1x4 are used for cross pieces.

Two inch stock 8 and 10 feet long is piled with only two cross pieces; 12 to 20 foot stock requires three; and stock 22 feet and longer usually four and sometimes five cross pieces. One inch stock 8 and 10 feet long is usually stacked with three cross pieces, and 12 to 20 foot stock with four.

By staggering the cross pieces so that there is only a 2 inch or 3 inch lap (Fig. 34), one side of each board is exposed to the air and the tendency of wide cross pieces to retard drying is reduced.

Two by fours are sometimes placed on edge to increase the capacity of the piles and to keep the edges straight. This is not common, however, and requires more time in piling.

Permanent cover boards are seldom used in Douglas fir yards. The covers are usually made by lapping two layers and double lengths of the stock in the pile (Fig. 34) and binding these down with a cross piece held by a rod or wire to sticks inserted in the pile. The use of the regular stock for cross pieces and pile covers does away with sticker and pile cover board costs, but it decreases the saving in freight rates and increases the amount of lumber depreciated in grade during the air seasoning process.

TIME REQUIRED FOR DRYING

The green heartwood of Douglas fir usually contains from 30 to 32 per cent of its oven dry weight in moisture, and the sapwood as high as 100 per cent. Because of the marked variation in the humidity of the atmosphere during the different months of the year, the rate of drying is not at all uniform. Under good drying conditions one inch fir lumber properly piled should reach an air dry state in from 45 to 60 days. During the winter months, when the humidity is high, one inch stock requires three or four months and dimension stock six or eight months to reach an air dry state even when properly piled. Lumber dried in winter is never as dry as that dried in summer because the moisture content of air dry wood always holds a definite relation to the humidity of the surrounding atmosphere.

The amount of moisture in lumber which has been thoroughly air dried (i. e. which has reached a constant weight) varies in summer from 10 to 12 per cent of its oven dry weight, and in winter from 16 to 18 per cent. Lumber which contains more than these percentages of moisture is not properly dried; and if shipped without further drying, it will cost the operator more for freight than is necessary.

In getting out rush orders it is not always possible to ship dry lumber, but many manufacturers are shipping lumber which is not thoroughly dry because no accurate means have been used to ascertain whether the material to be shipped is dry. The usual practice is to date the pile when com-

pleted and leave it there a specified time, if possible. No consistent record of weather conditions is kept, so that the piles are seldom dry when taken down unless the weather has been extremely favorable. At some plants the yard boss uses his judgment in the matter and endeavors to take the weather into consideration, but he has no records of the weather, and his decisions are largely guess work.

Few operators have paid sufficient attention to the weight of the product shipped; for they are misled by the fact that there are always enough underweights to give the impression that the lumber is dry when the freight is checked up against the estimated shipping weight.

For operators who desire to determine the moisture content of their air dry stock before shipment, the following procedure is suggested. When the piles are being constructed, provision may be made for removing three or four sample pieces from each pile (particularly from points where drying is likely to be slow) by placing small blocks of wood (slightly thicker than the lumber) on the cross pieces on either side of the board to be removed. A wedge-shaped piece is placed also on the board below and directly in front of each cross piece, so that the sample pieces can be slid back into the pile if desired without striking the cross pieces. These sample pieces are marked on the one end with red crayon to be identified easily. When the pile is completed or at some other convenient time the test pieces may be removed and a 12 inch piece sawed from the end of each and thrown away [1]. Then another piece 12 inches long is sawed off, and corresponding pile numbers and piece letters are placed on both the original board and the piece cut off. These are for identification and reference. Both pieces are carefully weighed (within 1 per cent) and their weights marked on the respective pieces or in a note book, or both. The small pieces are put in the dry kiln and left there until repeated weighings fail to show any loss of moisture [2]. The absolute dry weight is determined for each piece and the following calculations made to determine the moisture content in per cent.

The percentage of moisture in the piece is ascertained by dividing the original weight by the absolute dry weight and discarding the figure 1 to the left of the decimal. The remaining figures represent the percentage of moisture in terms of the dry weight. For example, if the small piece weighs 40 ounces originally and 30 ounces absolutely dry, the moisture content is 33.3 per cent before drying ($40/30=1.333$). The corresponding large pieces must have had 33.3 per cent moisture also, and to determine what it should weigh when dried to 12 per cent moisture (summer air dry condition), the following calculation is necessary. Assuming that the green weight of the large piece was 60 pounds:

$$\begin{aligned} 60:1.33 \; &: \; : x : \; 1.12 \\ 1.33\, x &= 67.2 \\ x &= 50.4 \end{aligned}$$

According to the calculation the large piece must be left in the pile until it weighs only 50.4 pounds before it is thoroughly air dried.

Where it is not possible to weigh the large pieces in the yard the moisture determination may be postponed until just before the pile is taken down, and calculations may be made on the small samples, or yard scales may be installed for weighing truck loads or a number of boards.

OPERATIVES AND THEIR DUTIES

Piling in the yard is usually done by experienced men working in crews of two. One stands on the ground or truck and hands the material up to the man on the pile. The piler must be skilled in building the piles neatly

[1] This is to prevent end drying from disturbing the calculations.

[2] These repeated weighings are not necessary after the time required to reach constant weight under given conditions has once been ascertained.

and with reasonable speed. In taking the lumber down the operation is reversed and often done under the supervision of an inspector, who grades and tallies the pieces to be shipped. Two men can pile from 3,000 to 6,000 feet per hour, depending on their skill and the class of stock handled.

LUMBER PILING MACHINE

A machine for piling and unpiling lumber has lately been placed on the market and is said to be well adapted to handling lumber rapidly and economically under certain conditions. It is of especial value where yard space is limited and the capacity of pile bases must be increased or where large high piles of lumber can be built without tying up too much stock during the construction of the piles.

The machine (Fig, 44) consists of an endless chain elevator equipped about every 4 feet with double brackets upon which the boards are conveyed in a horizontal position, over the top of the machine and down to a point where they can be reached by the man on the pile. The entire equipment is mounted on a car (having either flanged or flat wheels) upon which it is moved around the yard. The machine requires very little power. The speed of the chains can be regulated according to the number of men engaged in the work. A crew of three men is ordinarily employed, one on the ground and two on the pile.

The machines in use at present are of various heights from 24 to 40 feet. The capacity varies with the size of the lumber. Machines used for all sizes of material are said to have averaged more than 10,000 board feet per hour, which would indicate that certain sizes have been handled at a much greater rate. The chain normally moves at 30 feet per minute; i. e., eight boards per minute are raised to or lowered from the piles.

The machines shown in Fig. 44 can be obtained complete with electric motor and extension wire cord at the following prices:

COST OF PILING MACHINE (1916)

Size of piler, ft.	Weight, lbs.	Cost (f.o.b. Seattle), $
24	6,000	850
26	6,500	900
30	7,500	1,000
40	10,000	1,150

Similar pilers equipped with gasoline engine drive can be obtained at slightly higher prices.

COST OF AIR SEASONING

The average labor cost of hand piling for air seasoning varies from 17 to 25 cents per 1,000 feet. For unpiling, the cost, exclusive of grading, is from 12 to 20 cents. In addition, there is a small amount of lumber (about 15 per cent) on the average for all grades and sizes which must be rehandled after drying because it falls in grade during seasoning. This may either be left on the ground in front of the pile and shipped when an order is received for it or it may be hauled to a pile of such material. The latter procedure keeps the yard in an orderly condition and facilitates inventorying and assembling for shipment.

In many plants the scarcity of trucks often necessitates placing lumber on the ground in front of the piles temporarily, awaiting the arrival of the piling crew. The amount of lumber so handled is from 10 to 30 per cent. This increases the total handling cost from 1 to 3 cents per thousand.

The average labor cost of piling, unpiling, and rehandling, exclusive of transportation, is from 35 to 50 cents per thousand feet air dried.

LABOR

The following cases are illustrative of the cost of handling stock on contract in the yards of Douglas fir mills.

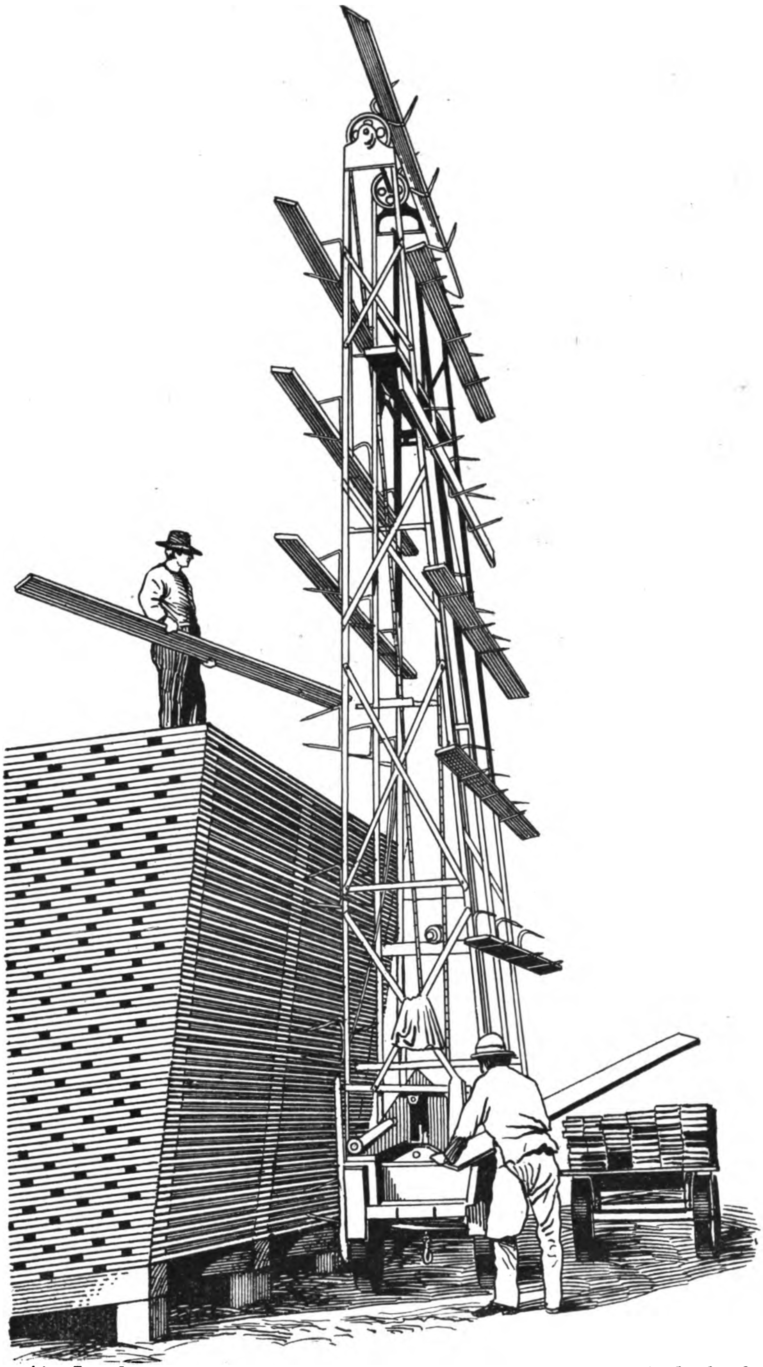


Fig. 44. Lumber piling and unpiling machine. (Also shows method of piling boards parallel to machine.)

Case No. 1.—50,000 feet handled daily: unloading trucks—14 cents per 1,000; piling—25 cents per 1,000; unpiling—14 cents per 1,000.

Case No. 2.—25,000 feet handled daily: unloading trucks—16 cents per 1,000; loading trucks—12½ cents per 1,000; piling 1 x 8 inch and wider, and 2 inch—18 cents per 1,000; piling 1 x 4 inch and 1 x 6 inch—22 cents per 1,000; unpiling—14 cents per 1,000.

Case No. 3.—600,000 feet handled daily: piling all sizes and lengths up to 32 feet—17 cents per 1,000; piling 32 feet and longer—25 cents per 1,000.

Case No. 4.—200,000 feet handled daily: piling—all stock regardless of size—22 cents per 1,000.

Case No. 5.—60,000 feet handled daily: unloading trucks—12½ cents per 1,000; loading trucks—12½ cents per 1,000; piling 2 x 4 inch to 12 inch—16 cents[1] per 1,000; piling 1 x 3 inch to 12 inch—20 cents per 1,000; piling 3 x 4 inch x 4 to 12 inch—20 cents per 1,000.

Under careful supervision contract labor is very satisfactory and economical. It also has the advantage of giving definite cost information. It has the disadvantage of necessitating tallies of all stock handled; but the saving offsets such expense many fold and the additional information is in itself worth the cost of making the tallies.

YARD SUPPLIES

Usually the only supplies for air seasoning that figure in the cost are stickers and cover boards[1]. Stickers cost from 2 to 3 cents per 1,000 of lumber piled with them. Cover boards cost from 1 to 2 cents per 1,000 feet of lumber covered. They are not common at fir yards.

Where the yard is covered by a shed pile covers are eliminated, and there is, besides, less depreciation of stock from sun checks. The product is also protected from rains, which greatly increase the shipping weight during wet weather. There are only a few yards under cover in the fir region. It is very probable that there will be more when all the advantages are better understood.

YARD REPAIRS

Costs for repairs in connection with air seasoning are almost negligible, since the transportation costs cover repair to gangways. The only other expense is for keeping the pile bottoms in satisfactory condition. Ordinarily, this is small (less than a cent per 1,000) unless the foundations are on soft ground or on piling in salt water.

COST OF PILE BOTTOMS

Pile bottoms vary in cost from $.40 to $1.50 per linear foot of pile width. The following average costs are for the typical kinds:

Solid ground:	
3 bents[1]	$0.40 per linear foot.
4 bents[1]	.53 per linear foot.
Swamp:	
3 bents[2]	1.00 per linear foot.
4 bents[2]	1.33 per linear foot.
Tideland:	
3 bents[2]	1.20 per linear foot.
4 bents[2]	1.60 per linear foot.

Since it takes about 1 linear foot of pile bottom for each 1,000 board feet of yard stock carried, the cost for yards of various sizes can be computed readily.

[1] Lumber up to 20 feet stuck with same stock; 22 foot and 24 foot stock stuck with 1 x 4 x 12 foot stickers.

[1] Lumber for tram repairs is taken care of under transportation.

[1] Supported on blocks of wood.

[2] On piling.

SHEDS FOR ROUGH DRY LUMBER

Only a very few Douglas fir mills are equipped to store the rough dry stock. The practice is to run Douglas fir into specific forms in advance of orders. This tends to break the market when there is a reduced demand for a given form and it must be moved to obtain room or to obtain working capital. The use of sheds for rough lumber permits storing the stock in a form suitable for the manufacture of a variety of products. It also insures sufficient material to keep the planing mill machines operating a reasonable length of time on stock of a given size and pattern.

Storage sheds for rough lumber are of various sizes and shapes. Their cost is about the same as that of the dressed storage sheds. Where sheds for rough lumber are used, the size of the dressed lumber sheds can be greatly reduced.

PLANING MILL

Nearly all Douglas fir plants have fully equipped planing mills. Many factors are responsible for the present practice of manufacturing finished forms at the sawmills instead of at independent wood working plants. The principal reason is that it reduces the weight of the product which must be shipped; the second is the economy in manufacture due to cheap handling and cheap power; and, third, is the desire to put the lumber into a form which can be handled by the retail yards without special equipment for finishing to suit the ultimate consumer.

The general layout of a Douglas fir planing mill of modern design is shown in Fig. 45[1].

BUILDINGS

The planing mill buildings are usually of the shed or one story type with end walls but no side walls. They are ordinarily from 80 to 100 feet wide and as long as necessary to accommodate the various machines. They are seldom less than 200 feet long, and range from this up to about 700 feet, including the sorting tables at the larger plants. In order to allow ample room, it is the practice to figure on about 16 feet for each machine and about an equal amount for each sorter. Details of construction of a planing mill building are shown in Figs. 46 and 47. The construction is not exactly

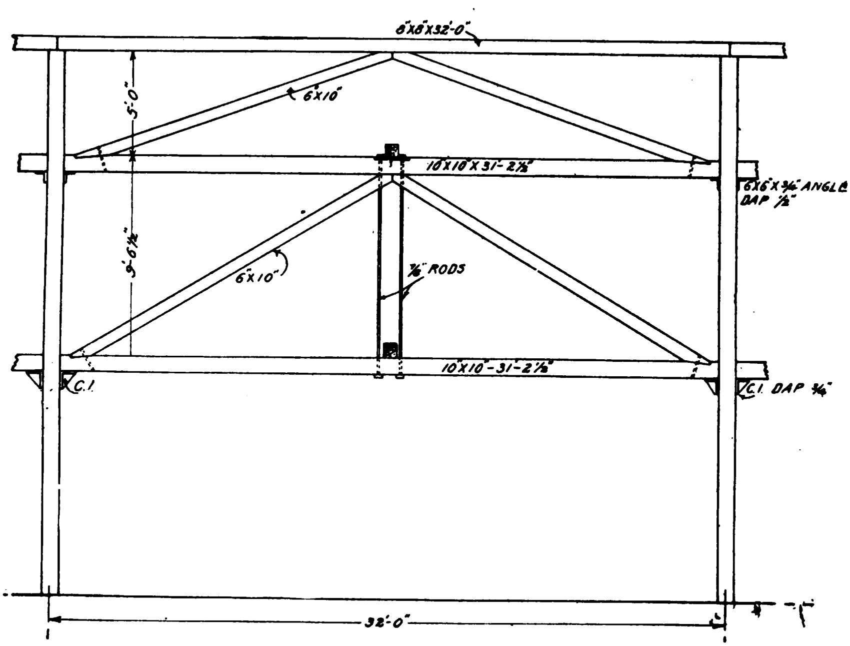


Fig. 46. Partial end elevation of a planing mill building and design of trusses to eliminate interior posts.

typical because of the oblique arrangement of the glass, which is designed to admit more light than is admitted by the usual vertical window. Good light is essential.

45[1] On page 124 and 125.

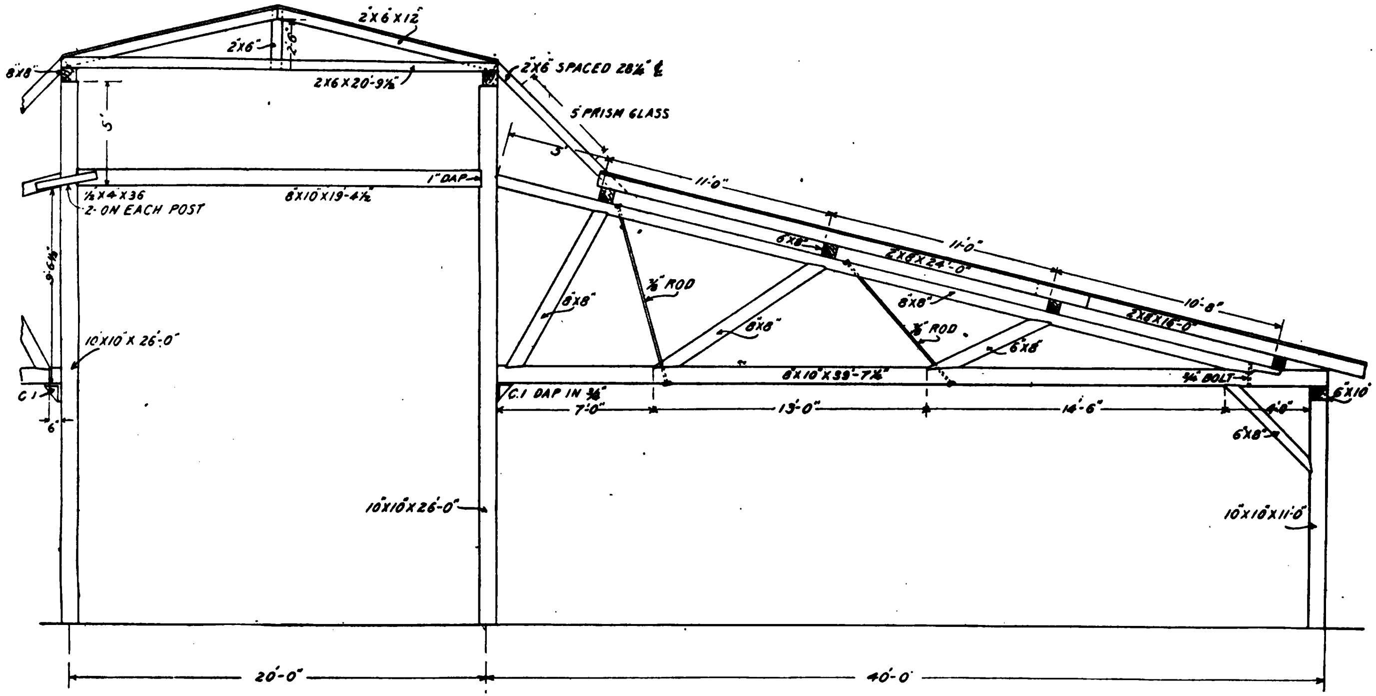


Fig. 47. Partial end elevation of a planing mill building and design of trusses to eliminate interior posts.

The following figures are illustrative of typical costs of such buildings.

COST OF PLANING MILL BUILDINGS, PER SQUARE FOOT OF FLOOR AREA (1916)

Item	High, Cents	Medium, Cents	Low, Cents
Foundations	4	3	1
Joists and floors	9	7	5
Superstructure and walls	13	10	8
Glazing and sash	6	4	3
Roofing material	5	4	2
	39	28	19

MATCHERS

A high speed matcher is shown in Fig. 48. This machine is designed for running such forms as flooring, ceiling, drop siding, and similar planing mill products at fast feed. It is made to take stock 6 inches thick and in two sizes up to 9 or 15 inches in width. It is too fast to be fed by hand and is used with automatic feed tables similar to those shown in Fig. 49. The operative places the boards upon the table, and the spiral rolls automatically move them across it and into the machine.

Fast feed machines of this kind can be operated at speeds between 100 and 400 feet per minute, and they are actually turning out from 100,000 to 200,000 linear feet of stock daily at some of the plants in the fir region. Actual feeds for such machines on flooring, ceiling, drop siding, and rustic are from 250 to 400 feet[1] per minute and on finish from 100 to 200 feet. Of course many plants are running such stock at a speed even as low as forty feet per minute, but only on machines equipped with few knives. The fast feed machines have 7 inch to 9 inch top and bottom cylinders with from 6 to 8 knives each. They are operated at a speed which gives about 9 or 10 knife marks to the inch.

APPROXIMATE COST OF MATCHERS (1916)

Size, in.	Approximate weight, lbs.	Approximate cost, $
6 x 9	18,500	3,200
6 x 15	19,500	3,300
6 x 20	21,000	3,400
6 x 24	21,400	3,500
6 x 30	22,000	3,600

The cost of wooden frame matcher feed tables like the one shown in Fig. 38 is as follows for tables having 5 rolls:

COST OF WOODEN FRAME MATCHER FEED TABLES (1916)

Size	Weight, lbs.	Cost delivered, $
30 inch rolls	3,500	450.00
36 inch rolls	3,750	475.00
42 inch rolls	4,000	500.00

Power for high speed matchers is usually supplied by a 50 h. p. motor, costing about $560 with pulley and base. The feed table can be operated from the same motor by means of an extra pulley on the main shaft or from a special pulley provided on the machine. In addition, a 15 h. p. motor, 1,800 R. p. m., is used to run the profile attachment.

SURFACERS

In addition to the machines used for matching, moulding, and timber sizing, most plants are equipped with a general utility surfacer like the one shown in Fig. 50. Such surfacers will take stock from ½ inch to 10 inches thick and are made in three sizes for pieces up to 20, 24, or 30 inches wide.

[1] Since the above was written fast feeds are said to have become less popular and 250 feet is now considered standard.

They are not made for high speed work; but two pieces may be fed at a time, and they will turn out a large volume of work when used to their best advantage. They are usually fed by hand, altho they may be fed with tables

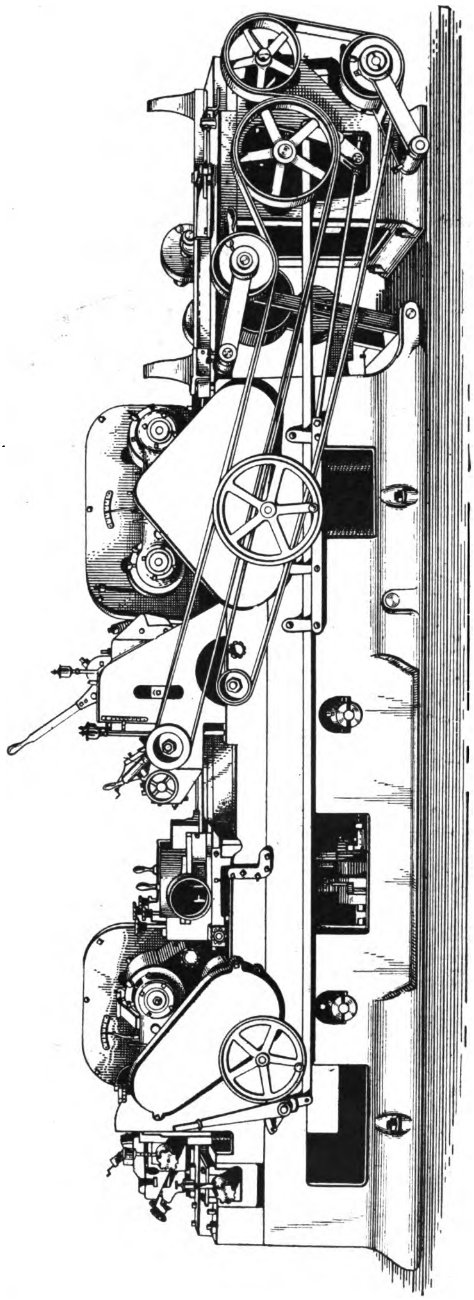


Fig. 48. High speed matcher with profile attachment.

(Fig. 49). It often takes two men to handle the stock to such machines, either because the machines are large or because of a desire to feed two pieces at a time. The machines are ordinarily run from 50 to 200 feet per minute.

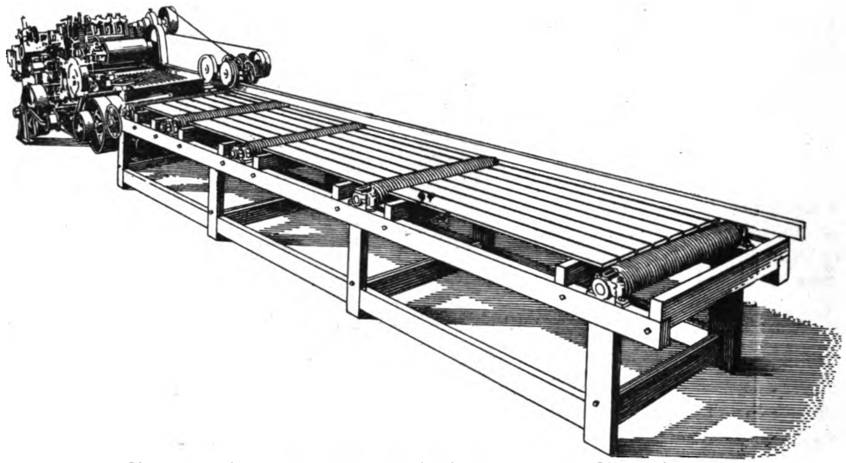


Fig. 49. Automatic feed table for planing mill machines.

The size, weight, and cost of large surfacers are as follows:

COST OF LARGE SURFACERS (1916)

Size, in.	Weight, lbs.	Cost at Pacific coast terminals, $
10 x 20	17,000	2,700
10 x 24	18,500	2,900
10 x 30	19,500	3,000

These surfacers are equipped with motors of from 50 to 60 h. p. of the same kind as those used on timber sizers.

MOULDERS

The typical moulder found in mills is designed primarily for making mouldings, casing, base, and similar moulded forms, although it can be used in emergencies for any class of work. The feed is ordinarily too slow to make it profitable to run the more common forms.

Machines like this are built in three sizes, for stock 8 inches and less and for widths up to 10, 12, and 15 inches. They run at feeds of from 25 to 125 feet per minute; the usual feed is 50 feet. Slow feed is necessary to insure good results, although most of these machines could probably be run faster than is the usual practice. The knives are run at about 3,800 R. p. m. One can feed a machine without any automatic feed table, but a table may be used if desired.

The approximate sizes, weights, and cost of moulders are given below. These costs include cylinders, cutterheads, and profile attachment, but do not include motors.

COST OF MOULDERS (1916)

Size, in.	Weight, lbs.	Approximate cost f.o.b. coast terminals, $
8 x 10	10,000	1,350
8 x 12	10,500	1,400
8 x 15	11,500	1,450

The motors in use on moulders at Douglas fir planing mills vary from 25 to 50 h. p. While power data are lacking, it is believed that the smaller size is ample unless extremely fast feeds are to be used.

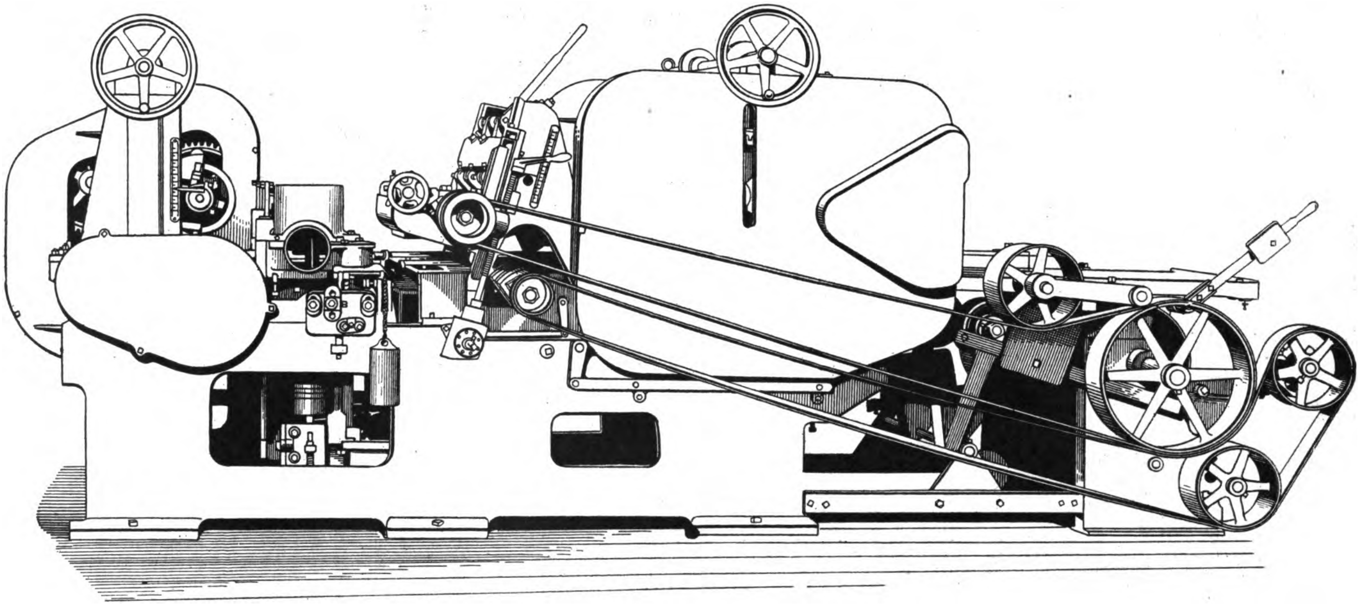


Fig. 50. Surfacer and sizer for boards and planking.

READY SIZERS

Ready sizers are commonly placed in the re-manufacturing plant or on the sorting chains, so that they are often an integral part of the sawmill; but since the operation is surfacing or planing, they are really a part of the planing mill equipment.

Sizers are designed for rapid surfacing of dimension stock in random widths and thicknesses just as it comes from the mill. They are meant for use where they can be kept supplied with large and continuous quantities of miscellaneous stock taken from the chains and sized before being sorted. They are not efficient unless kept in constant use; and there is usually a tendency to size too much stock in an endeavor to keep them busy. Some operators prefer to run the machines only as needed and to supply stock in units to increase their capacity by eliminating the shifting of guides.

Sizers are usually built to take stock up to 26 inches wide and 16 inches thick, the minimum being 3 inches and ¾ inch respectively. Some of them are also made to take shiplap as well as dimension without changing heads, and are thus general utility machines.

They are sometimes fed at a speed of 250 feet per minute and equipped with automatic feed tables. Some are designed to take two pieces at once at a feed of 160 feet per minute, making an equivalent of a feed of 320 linear feet.

Sizers are ordinarily built in two sizes and with or without special arrangement for making shiplap.

COST OF SIZERS (1916)

Size, in.	Weight, lbs.	Cost delivered, $	Extra for shiplap, $
10 x 30	21,000	3,150	450
16 x 30	21,500	3,250	450

The following power data were taken on an 8 inch x 20 inch ready sizer fed at 250 feet per minute. A 50 h. p. motor costing about $560 will operate this machine.

Input running light	10.0 Kw.
Average input throughout day (not including delays)	34.8 Kw.
Maximum input instantaneous	95.0 Kw.
Maximum input sustained	54.0 Kw.
Average input sustained	37.0 Kw.

COST OF SURFACING AND MATCHING

The following estimates of the labor cost of machining planing mill products give the range per thousand board feet, exclusive of trimming, grading, and bundling.

COST OF SURFACING AND MATCHING

Size of stock, Inches	Cost per thousand board feet, Low, cents	Intermediate, cents	High, cents
1 x 4 flooring and ceiling	8	18	25
1 x 6 flooring and drop siding	6	12	16
1 x 8 finish	8	18	25
1 x 10 finish	6	14	20
1 x 12 finish	5	12	18
2 x 4 dimension	6	9	15
2 x 6	4	6	10
2 x 8	3	4	7
2 x 10	2.5	3.5	6
2 x 12	2	3	5
2 x 14	1.5	2.5	4
1 x 6 boards and shiplap	8	12	20
1 x 8	6	8	15
1 x 10	5	7	12
1 x 12	4	6	10

CUT-OFF SAWS

Small swing cut-off saws are used for trimming out defects in the planing mill products. They are made in two sizes for light and heavy work.

The large size carries 18 to 30 inch saws and the small size 14 to 16 inch saws. A motor driven saw is better than the shaft-driven one because it can be placed anywhere in the planing mill without regard to main and auxiliary shafting.

When most of the trimming is done by trimmer (Fig. 51) these cut-off saws are used to trim only a small amount of material which gets by the main trimmer. Otherwise a cut-off saw is usually placed along the planer sorting chains for trimming all the stock.

The large cut-off saws weigh 450 pounds and cost $55, not including the motor, while the small machines weigh 400 pounds and cost $50 (1916).

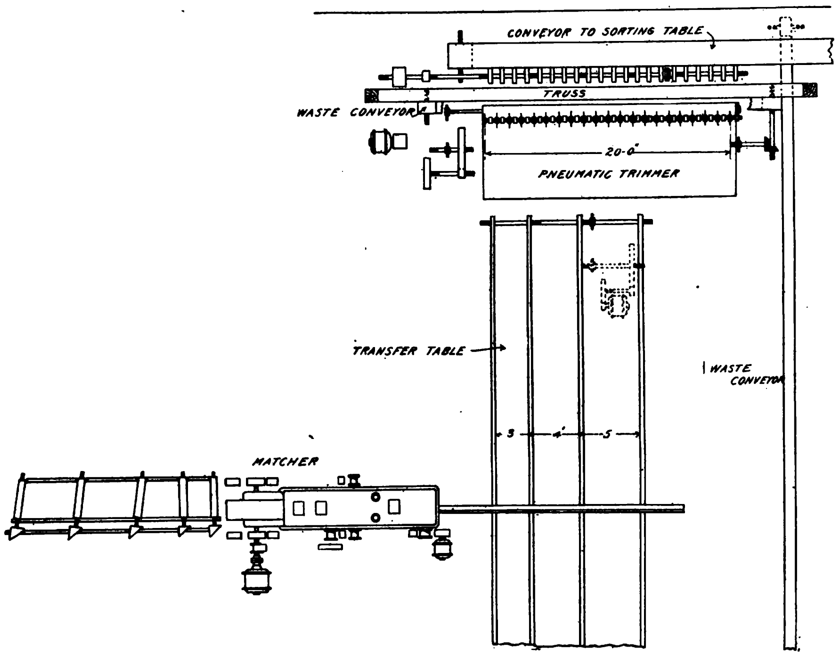


Fig. 51. Pony trimmer layout for planing mills.

PNEUMATIC TRIMMERS

In some of the larger planing mills the patterns put through the various surfacing and matching machines are deposited upon a transfer table (Fig. 45) and conveyed to a pony pneumatic trimmer similar to that used in the sawmill but having the saws spaced one foot apart instead of two. Details of such a layout are shown in Fig. 51. With this outfit one experienced man can trim the entire output of the planing mill at less cost than where there is a trimmerman behind each machine. The practice has been criticised on the grounds of true economy because the operative is said to work so fast that he cannot do his work properly, but there seems to be little difference in the actual results. The general scheme of operation is the same as that described for the sawmill trimmer.

The stubs on the feed table chains are spaced about 2½ feet apart and the chains are run at from 75 to 125 feet per minute, i. e., 30 to 50 pieces per minute.

Twenty-foot trimmers with 21 saws weigh 20,000 pounds and cost $1,800; 22-foot trimmers with 23 saws weigh 22,000 pounds and cost $2,000; and 24-

foot trimmers with 25 saws weigh 24,000 pounds and cost $2,200, (1916). The installation cost is about $200 additional. These costs do not include belts or saws.

Saws 16 inches in diameter and 14 gauge cost $4.00; 18 inches in diameter and 13 gauge, $5.00; and 20 inches in diameter and 13 gauge, $5.75. Those 16 inches in diameter are most common.

The size and cost of motors for pony trimmers is shown below. The 20 h. p. motor is most common, since most of the trimmers have only 21 saws. The same motor also drives the feed table.

COST OF MOTORS FOR PONY TRIMMERS (1916)

Size of motor, h. p.	Size of trimmer, No. of saws	Approximate weight, lbs.	Cost delivered, $
20	21	1,200	339
25	23	1,320	380
30	25	1,670	427

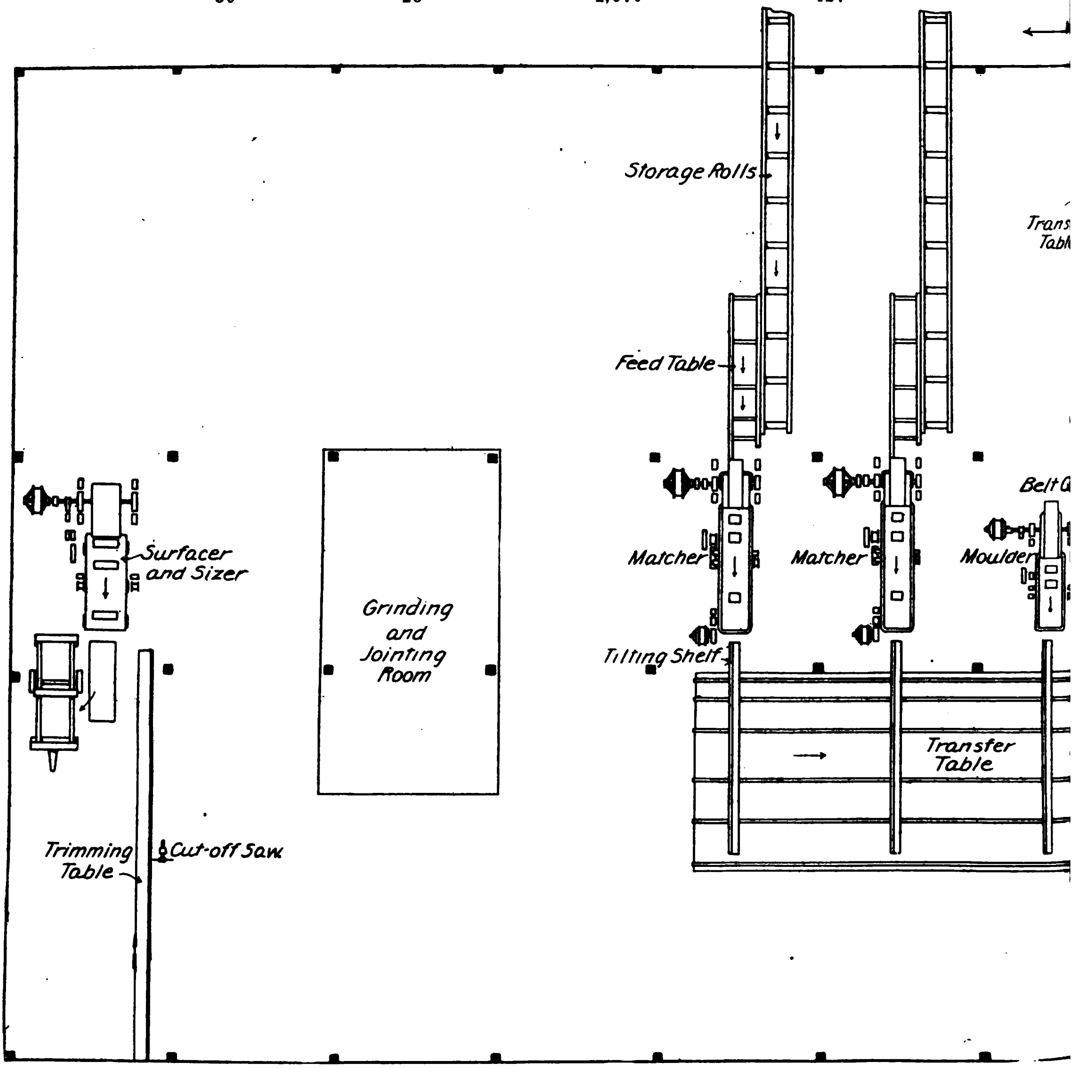


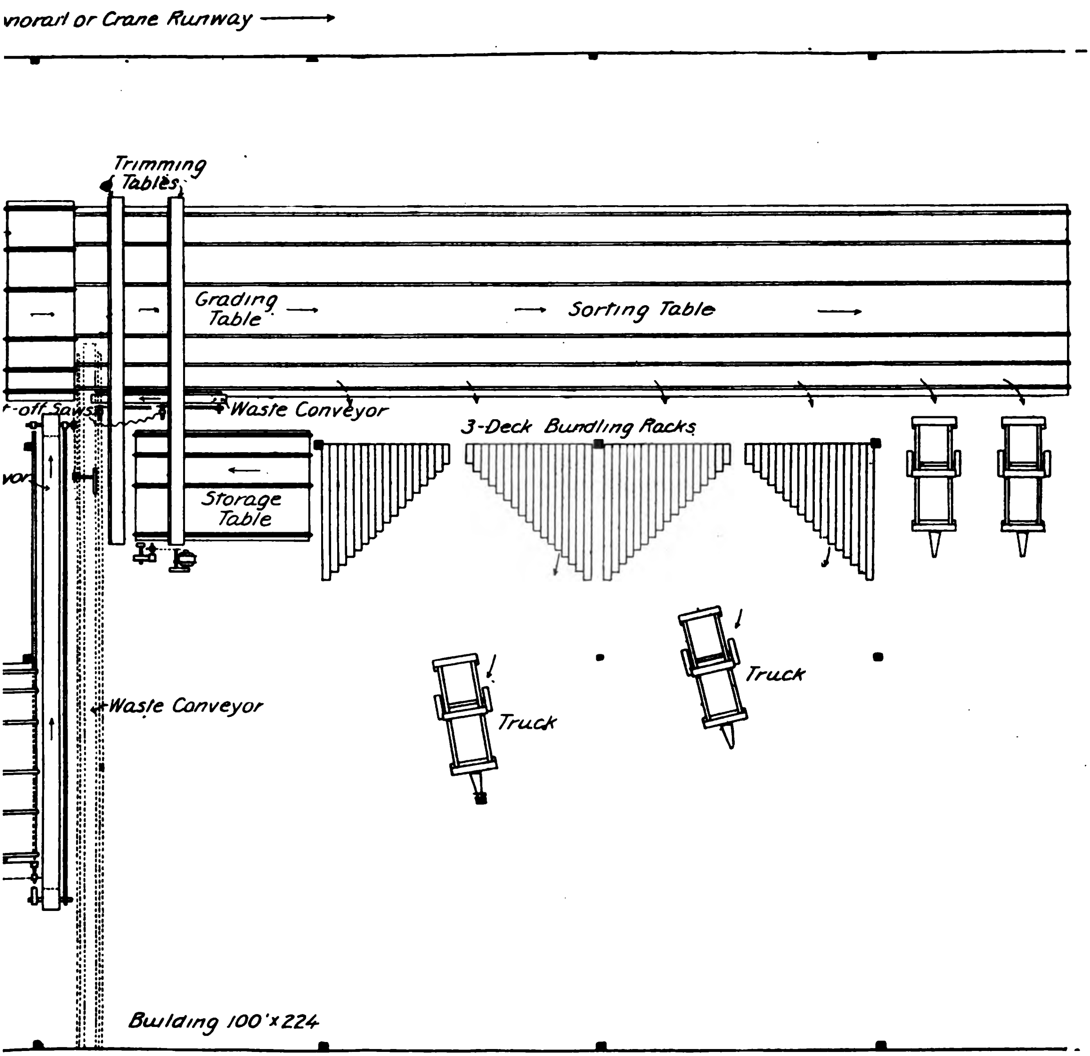
Fig. 45. Floor plan of

Complete with base, pulley, and starting compensator.

Smaller air compressors are required for these trimmers than for the large ones. The size usually employed is 9½ x 9½ x 10 inches, and it costs installed about $350, including a 30 x 72 inch tank.

COST OF TRIMMING

The cost per thousand feet of trimming planing-mill products varies with the average width, thickness, and length of the pieces and also depends upon the general grade of logs from which the stock is taken. In general, it varies from 5 cents for machine work to 18 cents for hand trimming and from 2 to 4 cents additional for hand work where the trimmerman also grades the stock. The average trimming cost for the region is about 10 cents and the average grading cost is 3 cents additional for stock graded.



ouglas Fir planing mill.

BAND RIP SAWS

Most rip saws are installed in the planing mill, although they are some times placed in the sawmill or along the sorting chains for use in re-edging or ripping green stock.

A rip saw can be obtained with or without a table. It might well be placed near the dry sorter, and used for ripping before the kiln dried stock is dressed. It would also have to be arranged in such a way that dressed pieces from the planing mill (or shed) which need ripping could be put through it. The band rip saw usually has wheels from 40 to 44 inches in diameter, and it is designed primarily for light work. The guide is adjustable to 20 inches at the right of the saw, which permits ripping very wide stock; and the rolls will elevate 14 inches. The table makes it possible to feed long pieces without trouble and without straining the saw and feed rolls. It is a general utility saw for all classes of ripping and can be used as a small resaw in emergencies.

The saws are 4, 5, or 6 inches wide and the tooth space varies from 1¼ to 2 inches. The prevailing space is about 1½ inches. The length of the saws is from 20 to 22 feet.

The saws are usually run at a speed of 10,000 feet per minute and the feed varies from 80 to 300 feet per minute, depending upon the thickness of stock being ripped.

Band rip saw machines for 4-inch saws, equipped with 44-inch tables, weigh 6,200 pounds and cost (1916) $925; those which use 5-inch saws cost $1,000 (1916). Machines without the table weigh 5,200 pounds and cost, respectively, $850 and $925. These costs do not include saws or motors.

Rip saws are usually equipped with 15 or 20 h. p. motors. The following power data, taken on a 44-inch machine fed 200 feet per minute, give an idea of their power demand.

Input running light...........................	7 Kw.
Maximum sustained input........................	23.7 Kw.
Average input throughout day...................	10.9 Kw.

Band rip saws are usually operated by two men, a sawyer and a helper. The sawyer feeds the stock to the machine and the helper stands at the rear and takes it away. Sometimes the stock coming from rip saws in the planing mill is sent on to a sorting table, in which case the helper's services are dispensed with.

SORTING AND BUNDLING PLANING MILL PATTERNS

There are two methods of sorting and bundling the product in Douglas fir planing mills. The old method, generally employed in the smaller mills, is to sort and bundle behind each machine. In the larger and new mills, where the lumber from all machines is deposited upon a common transfer chain, the sorting and bundling are done at a common point.

Where the sorting is done directly behind the machine, the trimming is also done there; and behind slow feed machines the trimmerman frequently grades or sorts the pieces, as well as trimming them on a cut off saw. The individual pieces are placed on saw horses and each grade and size is kept separate. When a proper number of pieces have accumulated in any pile, a bundler ties them in a package with lath cord, or wire, and places the bundle on a truck for delivery to the shed or car. One man can trim and sort, and another bundle and load upon trucks from 10,000 to 20,000 board feet per day, depending upon the width of the stock, i. e., the number of pieces to be handled to the thousand. When fast feeds are used and large quantities of stock are delivered from each machine, two or more trimmerman and bundlers are required. Where very fast feeds are used, as many as seven men are employed to trim, grade, and handle the product from a single machine operating upon flooring and similar 4 inch products.

In the larger mills where the patterns from the various machines are sorted from a common transfer table, grading is done by an inspector, who marks the grade on each piece. The pieces are then segregated into proper piles by sorter men working along the table. Where the bundling racks are placed directly above the table, these men also act as bundlers. Where the racks are placed at one side of the sorting table, the tying is done by bundlers, who also place the bundles on trucks for delivery to the shed or cars. Sufficient trucks are used to eliminate the necessity of segregating by grades in the dry sheds.

The cost of sorting tables depends upon their width and length and the number of chains. The figures given for light transfer tables will serve for estimates for the costs of these tables. They are usually from 10 to 12 feet wide and long enough to permit one series of length segregations for each machine.

The cost of sorting and bundling, exclusive of trimming, runs from 10 to 15 cents per thousand board feet in large mills where the stock is handled in quantities by large crews. In small mills, where the pieces are handled behind each machine and where interruptions in the work retard the sorting and bundling, the cost runs from 20 to 35 cents.

BLOWER SYSTEMS

An important, but not expensive, feature of each planing mill is the so-called blower system, used to collect the shavings and deposit them in the fuel bins or burner. The volume of material which they are required to take care of is indicated by the fact that from 25 to 40 per cent (or from 600 to 900 pounds per thousand board feet) of all the material fed into the planing mill machines is converted into shavings.

The shavings are conducted from each cylinder and cutter-head on each machine by separate intake pipes, ranging in diameter from 6 inches for a slow feed matcher or moulder to 11 inches for the top cylinder of a fast feed planer. The side heads require intakes from 6 to 9 inches. The fan produces a pressure "suction" of from 4 to 5 oz. per square inch at the intake, and this pressure is maintained throughout the system by keeping the total cross sectional area at the intakes equal to the cross sectional area of any of the receiving pipes. The cross sectional area of the exhaust usually equals that of the intake.

The following table summarizes the cost, weight, size, and operation of fans installed in typical operation. The costs are for the fans alone, exclusive of pipes and motors.

COST OF FANS (1916)

Size of fan, in.	Weight, lbs.	Cost, $	Power required, h. p.	Speed, R. p. m.	Number of machines	Speed of feed on machines, ft. per min.
35 x 11	540	85	12	2,300	1	80
50 x 20	875	135	25	1,300	1	150-300
80 x 32	2,400	370	35	950	3	150-300

The cost of constructing and installing the pipes, including solder, rivets, labor, etc., is about 12 cents per pound, or roughly, from $150 to $250 per machine (1916), depending upon the feed and size of the machines, distances to bins and other variables.

The weight most commonly used for piping up to 23 inches in diameter is 20 gauge; and for larger than 23 inches, 18 gauge. For intakes and elbows, 16 gauge is used. Twenty gauge iron weighs 1.75 pounds and 18 gauge 2.4 pounds per square foot. Therefore, a pipe 12 inches in diameter and made of 20 gauge iron would weigh 5.5 pounds per linear foot. The weight varies 0.5 pound per inch of variation in diameter. A pipe 23 inches in diameter and made of 18 gauge iron weighs 14.5 pounds per linear foot; and one 32 inches in diameter, 20.1 pounds, the weight being 2.4 pounds per square foot. This gives a variation of about 0.6 pound per inch of diameter.

CUTTER HEADS AND KNIVES

The revolving cutting or surfacing parts of the planing and matching machines are called cylinders and cutter heads. The cylinders work on the top and bottom faces of the boards and the cutter heads on the sides. Where either the top or bottom faces require special moulding, additional cylinders called profile heads are employed. The relative position of each of these rotating parts with respect to the board and the direction of feed is shown in Fig. 52.

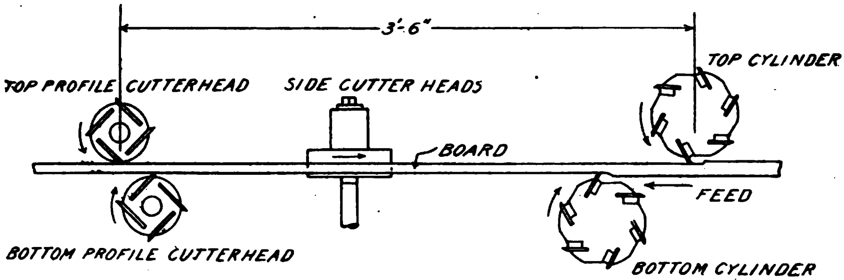


Fig. 52. **Relative position of cylinders and cutter-heads in planing mill machines.**

The cylinders are made to take from 2 to 8 knives, depending upon the cylinder diameter and the rate at which the stock is to be fed. They rotate at from 3,000 to 4,000 revolutions per minute, and the boards are usually fed at a rate which will produce 8 or 9 knife marks per inch. Therefore, it is obvious that the rate of feed depends on the number of knives to the cylinder and its r. p. m. The fast feed machines are therefore equipped with cylinders having the maximum number of knives.

The side and profile cutter heads are equipped with small cutting parts called bits. These are of two types, circular and straight.

The manufacturers of planing mill machines usually furnish an extra set of side cutter heads with each machine; but where a machine is used for a large variety of patterns, cperators usually purchase extra sets of cutter heads for each pattern. The costs of these are approximately as follows, depending upon the style, as well as the number of bits. The higher prices are for the self-centering cutting heads. Extra bits for these heads cost from one to three dollars each, depending upon their size. The three dollar cost is for large bits used in tongue and groove work on stock two inches thick.

COST OF CUTTER HEADS (1916)

Bits in each head	Price per pair of heads, $	Bits in each head	Price per pair of heads, $
3	12 - 15	8	25 - 30
4	15 - 18	12	35 - 45
6	20 - 25	16	65 - 125

Profile cutter heads equipped with six bits, for beaded and V work (3-heads) cost $60 to $75 per set, for channel rustic or drop siding (1-head), $60 to $75 each; for novelty rustic (1-head), $100 to $125. Where the unit profile attachments are used, the costs are the same for the same work. Extra knives for the cylinder cost from 20 to 50 cents per inch, measured along the cutting edge. The usual cost is about 25 cents per inch (1916).

Knives and bits cost from one to four cents per 1,000 feet of lumber, depending upon the size and character of the product made. The average cost is about two cents.

GRINDING AND JOINTING

The edges of knives and bits in the cylinders and cutter heads must be kept sharp and true to insure a smooth high grade product. To keep them so requires special apparatus, either attachments to the planing mill machines or separate machines placed in the grinding room. In the larger mills, it is the duty of one or more men to keep these cutting parts in condition for all the machines, but in the small plants the planing machine operators do such work themselves.

Grinding, the main sharpening operation, is done with special emery stones either wet or dry and shaped to give the proper form to the cutting edge. The long, straight, thin knives used in surfacing wide stock are usually removed from the cylinders and ground separately, but the knives and bits in the side and profile heads are ground while in the head.

After the cutting edges have been sharpened the cylinders or cutter heads are placed in a machine called a jointer and the edges evened up, so that each cutting part of each knife or bit revolves in the same radius. This insures a smooth surface and a uniform amount of work for each blade. Under ordinary conditions where the heads have to be jointed in the bearings of the jointing machine, it is extremely difficult to prevent slight unevennesses in the cutting radius. Some of the planing mill machines of recent design are made so that the profile heads and bearings can be taken to the grinding room intact and sharpened and jointed just as they are used in the machine. This insures good work.

Where a special grinding room is used, the equipment costs somewhat as follows: A knife grinder (30 inch), weighing 2,100 pounds, costing $400 delivered; a cutter head and cylinder grinder and a cutter head jointer. each weighing 800 pounds, costing $150 delivered.

About the same amount of power as is used in the sawmill file room is necessary in the planing mill grinding room.

The cost of grinding and jointing planing mill knives when special men are employed for the work varies from 2 to 5 cents per thousand feet dressed, depending upon the size and character of the product. The average is probably close to 4 cents.

DRESSED-LUMBER SHEDS

Storage sheds for planing mill products (Figs. 53 and 54) are an essential part of every Douglas fir mill, unless the output is shipped in the rough or green condition. These sheds have two main purposes, i. e., to permit the keeping of a sufficient stock of standard forms for immediate shipment and to store the surplus forms and grades manufactured in the preparation of orders. The latter used to be the chief function, but in recent years the desire to give better service has prompted many operators to enlarge their sheds in order to provide large stocks for immediate shipment.

The sheds in the fir region are one story high and from 40 to 200 feet wide by from 100 to 700 feet long. The following tabulation gives the size of sheds and stocks common in mills of typical sizes.

SHEDS AND STOCK

Size of mill, board feet annually	Normal shed stocks, board feet	Size of sheds,[1] Square feet
8,000,000 to 10,000,000	300,000 to 500,000	5,000 to 8,000
10,000,000 to 20,000,000	500,000 to 1,000,000	8,000 to 15,000
20,000,000 to 30,000,000	1,000,000 to 2,000,000	15,000 to 25,000
30,000,000 to 40,000,000	2,000,000 to 2,500,000	25,000 to 30,000
40,000,000 to 60,000,000	2,500,000 to 3,000,000	30,000 to 35,000
60,000,000 to 75,000,000	3,000,000 to 4,000,000	35,000 to 40,000

[1] Not including loading shed.

The compartments in the main shed are 10 x 14 feet and have a capacity of from 18,000 feet of 10 foot material to 36,000 of 20 foot material each.

With an average of 27,000 feet, the 128 compartments will hold about 3,500,000 feet of lumber; but the working capacity is not more than 2,500,000 or about 75 board feet to each gross square foot of shed capacity, including alleyways. The lean-to will provide for about half a million feet of short length stock, or 50 board feet of lumber per square foot of total inside area.

The following detailed figures for the cost of completed sheds are representative:

COST OF SHEDS

Part	Cost per square foot. High, cents	Medium, cents	Low, cents
Foundations (floor area)	10	3	1
Floors (floor area)	10	8	6
Walls (wall area)	3	2.5	2
Superstructure (floor area)	12	10	8
Roofing material (roof area)	5	4	3

The so-called end piling method of stacking is almost universal among fir operators. The stock is much more easily handled, and the bundling cords are less likely to be broken or pulled off in handling. The floor space is divided into a sufficient number of compartments (Fig. 54) to permit reasonable segregation of the products, keeping the sizes usually shipped in the same car as close together as possible, so as to facilitate assembling for shipment.

The short lengths are usually flat piled and sometimes placed in a "lean-to" at the side of the main shed.

Gangways or aisles from 10 feet to 16 feet wide give access to the various compartments, except where shed handling is done by overhead crane or monorail.

The shed work is not handled uniformly at fir mills, although the usual practice is to have one or two men unloading trucks and storing the product away, or loading trucks for shipment. In some plants the car loading crews go into the shed and select the material for each shipment. This system has the advantage of keeping the loading crew constantly occupied but tends to retard the loading operation.

One man can unload by hand from trucks and store away, or take down and load on trucks, from 25,000 to 35,000 feet of planing mill products per day. The labor cost varies from 10 to 25 cents and averages close to 15 cents for each thousand board feet handled through the shed. The usual contract price for this class of work is 12½ cents per 1,000. The cost depends upon the average size of the material and the distances it is carried by hand to the compartments.

The shed repair costs are usually limited to replacing the planking in the aisles and to other minor repairs. The repair of the planking is naturally a part of the transportation cost and may properly be figured as such.

Some of the more progressive operators have developed a new method of tallying the lumber put into and taken from the shed. A slate or tally sheet is placed at each compartment and upon it the men tally each bundle or piece put in or taken from the compartment. In addition to forming a perpetual inventory, this system affords an accurate tally of the material handled and forms a basis for paying the men for work done by contract.

SHIPPING

The shipping operation as classified at some plants includes taking down the lumber from piles in the yard and in the shed, but in this bulletin it is restricted to actual loading of cars or barges, grading and tallying, and handling cargo shipments on the docks. This is a rather arbitrary restriction and possibly open to some criticism, but it makes the subject easier to treat from the standpoint of investments, costs, and methods.

GRADING AND TALLYING

When material which has not been previously graded is loaded, an expert grader often inspects and tallies each piece. He ordinarily inspects the lumber at about the same rate as it is loaded, and the cost of grading and tallying varies from 8 to 20 cents per 1,000, depending upon the same variables as does the loading. This expense is seldom actually incurred; for most of the head loaders are inspectors, and they inspect and tally the boards as they load them.

Frequently, the inspection at the time of loading is only very superficial and made to serve as a check on previous work at the sorting chains or in the yard. In such cases the work is done by the loaders and the cost is negligible.

LOADING CARS

BY HAND

When cars are loaded by hand, the work is usually done by crews of two. One man stands outside the car door and hands the material to the other, who stows it away in the car. Their work is made easier by the use of a stand, and a roller suspended in the door. The man outside lifts one end of the board from the truck, so that the middle portion rests on the stand and then swings the far end over until it rests on the roller and is easily shoved into the car. Some skill is required to stow the lumber in such a way that it will not shift around and become damaged en route and to utilize the full capacity of the car.

When three-wheel or four-wheel trucks are used, the load can be backed into the door of the car, and one man working alone can load from 75 to 80 per cent of the car as rapidly as two men can load in the usual manner. Two men are required for the remaining portion, since the man working in the gradually diminishing space must have the material handed to him.

Loading is said to be easier if the half of the car farthest from the door is loaded as high as a man can reach before the lumber is placed on the entire floor of the car, and the other half built up to a point high enough to enable building the first half to the top.

The loading platform is sometimes elevated 3½ or 4 feet above the level of the car floor, so that the lumber can be slid down into the car and little or none of it need be raised even when the car is nearly filled to the top.

The rate of loading is from 1,500 board feet per man per hour for planing mill products and dimension to 4,000 feet of timbers per man per hour, depending upon the size of material, accessibility of lumber and method employed.

The labor cost of loading cars by hand exclusive of grading, but including tallying, varies from about 10 to 30 cents, depending upon the size and kind of material, convenience in handling, and the method employed, as well as the wages paid. The usual costs for planing mill products and dimension lumber are from 20 to 25 cents per thousand, and for timbers and ties from 10 to 20 cents. Contracts were in effect in 1916 on the basis of from 12 to 16 cents per 1,000 for the mill products and dimension and 8 cents for the timber and ties including tallying.

Lumber and nails are used in securing the loads on flat and gondola cars. Since only about one-third of the Douglas fir shipments are made in such cars, the cost is execeedingly low. About 200 feet of lumber is required to the car, or eight board feet to the thousand. Figuring lumber and nails at $10 per 1,000, this amounts to 8 cents for each 1,000 feet loaded in such cars, or about 3 cents per 1,000 for the total shipments from the plant.

The cost of tally sheets and other shipping forms is usually included in office supply costs.

Shipping repair costs are negligible at plants when loading is done by hand; for there are few repair costs chargeable to shipping except those in connection with the transportation of the material to the cars, which are discussed under the subject of transportation.

BY MACHINE

Flat and gondola care are being successfully loaded by machine. Dimension lumber is handled in units of from 1,500 to 2,000 feet and placed on the cars a unit at a time. Small timbers and ties are also handled in units, while large timbers are handled a piece at a time.

A crew of three men is employed. One man operates the crane, one fastens a sling to the unit or tongs to the timbers, and the other unfastens these devices and supervises the loading. Loading can be done at the rate of from 10,000 to 40,000 feet per hour, depending upon the size of material and the skill of the operatives.

Cranes properly arranged would be of considerable assistance in loading closed cars, by placing units partly in the car doors so that they could be reached easily and stored by a single loader.

The labor cost of loading lumber upon flat and gondola cars by machine varies from 3 to 7 cents per thousand, exclusive of grading, depending upon the size of the material and the type of mechanism used. The cost of lumber and nails for securing the loads on flat and gondola cars is the same as for hand-loaded material.

When the lumber is loaded by means of mechanical devices, repairs of such equipment must be charged to shipping. Such costs, where available, are given under the discussions of the machines.

LOADING EQUIPMENT

CAR DOOR ROLLERS

Where two-men loading crews are used and it is necessary to hand the material from trucks into the car, the car door roller greatly facilitates loading. Such a roller costs $4.50 and comes in two sizes, 4 ft. 9 in. and 5 ft. 9 in. For car doors of different widths the screws will prolong the distance 11 inches.

CAR MOVERS

Even where the cars are carefully spotted, it is often desirable to move them a few feet to facilitate loading, and for this purpose a car mover is very useful. The bit that bites on the rail of these movers is replaceable when worn out. The movers cost $5.00 each and the new bits 10 cents a piece.

DOCK HANDLING

The docks at cargo and combination cargo and rail mills are built of wood. Most of the piling is Douglas fir, although some is Sitka spruce or western red cedar. Creosoted piling is little used, since only in a very few cases have docks at Douglas fir mills been badly damaged by the attacks of teredo or other marine worms.

The piling is usually placed on 10-foot centers, to insure safety under extreme loading and to make the docks as rigid as possible. The caps and stringers are ordinarily of 12 x 12 inch timbers and the joists of 4 x 12 inch, although in a few cases 3 x 12 inch joists have been used. The

planking is either 3 or 4 inches thick. Good construction calls for 4 inch planking on the areas of traffic; and some builders use the heavy planking throughout, since the additional cost is not excessive and greater wear and rigidity are obtained. Wood blocks are coming into use to surface such docks and should give excellent satisfaction.

The following table will serve as a guide in estimating costs of docks of various widths. An endeavor has been made to use conservative figures, and the table is supplemented with notes for use in modifying the calculations.

COSTS OF DOCKS, INSTALLED (1916)

Length of piling, ft.	Size of joists, in.	Thickness of floor, in.	Cost per square foot of deck surface for typical widths, 20 ft. $	30 ft. $	40 ft. $	50 ft. $	100 ft. $
30	3 x 12	3	0.197	0.187	0.181	0.178	0.172
	4 x 12	3	.206	.196	.190	.187	.181
	4 x 12	4	.225	.214	.208	.205	.199
40	3 x 12	3	.219	.206	.199	.196	.188
	4 x 12	3	.232	.215	.209	.205	.197
	4 x 12	4	.246	.233	.224	.222	.215
50	3 x 12	3	.236	.221	.214	.209	.200
	4 x 12	3	.245	.230	.223	.215	.210
	4 x 12	4	.264	.248	.241	.236	.228
60	3 x 12	3	.262	.245	.236	.230	.220
	4 x 12	3	.271	.253	.245	.239	.229
	4 x 12	4	.289	.272	.263	.257	.247

Note.—Lumber is figured at $10 per 1,000; labor and hardware at $8; piling at $2.40 for 30 ft., $3.60 for 40 ft., $4.50 for 50 ft., and $6 for 60 ft; driving at $1.75, $2, $2.25, and $2.50, respectively. Piles 10 ft. centers—joists 2 ft. centers.

For costs of docks when creosoted piling is employed, increase the above costs as follows: 30 per cent for 30 ft. piling, 40 per cent for 40 ft. piling, 50 per cent for 50 ft. piling, and 60 per cent for 60 ft. piling.

Cargo shipments are not loaded by the mill crew except in a few instances in which some of the large producers operate their own boats to California and Atlantic Coast points. Ordinarily, the lumber is transported to the docks and stored there until the arrival of the boat. Sometimes it is left on the trucks, but more frequently it is close piled along the dock within reach of the ship's tackle.

The grading and tallying of practically all cargoes of fir are done by representatives of the Pacific Lumber Inspection Bureau as it is being assembled on the dock or at the time the shipment is being loaded. The Bureau then issues a certificate of inspection and a certified manifest. The cost of such inspection varies from 10 to 20 cents per 1,000, depending upon the time required in loading. The Bureau charges $5.00 per day (1916) and expenses for each inspector.

When the lumber is not left on trucks and must be close piled on the docks, the labor cost for handling varies from 5 to 20 cents per 1,000, depending upon the size of the material and whether or not mechanical devices are employed. At one of the large cargo plants where cost figures for dock handling were obtained, the labor cost was 16 cents per 1,000 for hand work. At some of the larger plants where cranes, monorails, etc. are used, the average cost is low; at other plants where the docks are small and the material must be piled to a considerable height by hand, the costs are very high.

Where deep water vessels cannot dock close to the mill, the lumber is loaded upon barges and lightered to deep water. It is close piled on the barges in much the same manner as when it is stored on docks, and the costs of handling are about the same.

The barges are usually from 25 to 30 feet wide and from 100 to 125 feet long and hold approximately 150,000 board feet of lumber when loaded to capacity. They cost from $5,000 to $6,000 each. The maintenance of these barges is negligible, and about the only extra expense in handling shipments in this manner is for tugs. Tugs powerful enough to tow the barges can be chartered for from $30 to $40 per day.

POWER

Electric power is rapidly coming into general use in both the saw and planing mills of the Douglas fir region. Practically all of the larger and better class mills built in the last few years have been equipped throughout with electric motors.

The more important reasons for increased use of electric power are:

1. Electric mills require only two-thirds as much power as shaft-driven plants.
2. Maintenance costs for belts and oils are considerably less than in the shaft-driven mills.
3. The fire insurance rate is less.
4. Machines can be placed and operated independently of one another. This increases efficiency through better arrangement and constant operation.
5. Modifications in and additions to plant equipment can be made without great expense.
6. While the power plant costs considerably more per installed horsepower, the saving in power required and in shafting, boxes, belts, etc., makes the net cost of electric mills (including motors) about the same as shaft driven plants.
7. Independent engines and engineers for planing mills are not necessary at electric plants.

POWER REQUIREMENTS

Records taken at Douglas fir saw and planing mills indicate that from 4 to 6 electrical horsepower are required per thousand feet of cut per day (10 hrs.) or from 30 to 45 kilowatt hours for each one thousand board feet of lumber produced. In addition, from 100 to 200 horse power of boiler capacity are necessary for the dry kilns, the steam carriage feed, and the various steam cylinders about the plant.

BOILER PLANT

Most of the boilers at Douglas fir mills are of the horizontal tubular type. The usual size is 72 inches x 18 feet with a rated capacity of about 150 h. p. and an actual capacity with Dutch oven settings of about 300 h. p. under the usual working conditions with from 100 to 150 pounds steam pressure.

Another type of boiler which is slightly more expensive at first, but which has excellent steaming properties and low maintenance, is the vertical water tube boiler.

FUEL

The fuel is usually sawdust, shavings, and hogged waste. It is fed into the fire box by gravity. About five-tenths of one cubic foot of hogged mill waste is required for each horsepower hour developed. At circular mills from 55 to 60 (from 1,200 to 1,500 pounds) cubic feet of sawdust are produced with each thousand feet of lumber and at band mills from 35 to 40 cubic feet (from 800 to 1,000 pounds). In addition, there are from 600 to 900 pounds of shavings produced from each 1,000 board feet of stock sent to the planing mill. The planing mill shavings average 8,500 B. t. u. per pound as fired and the sawmill waste about 5,000 B. t. u. as fired. The difference is due to the fact that the sawmill waste has about 50 per cent moisture, while the shavings have about 5 per cent.

STEAM TURBINES

The electric generators at Douglas fir mills are of the turbine type. The usual sizes of turbo-generator units are 500, 600, 750, 1,000, and 2,000 Kw., 3 phase, 60 cycle, and 3,600 R. p. m. The voltage used in the early plants was 440, but experienced electrical engineers are now recommending 550.

The costs of these turbines are given later under the cost of complete power plants.

MOTORS

Squirrel cage motors are used for sawmill work wherever possible because of their simplicity and strength. The data on motors in this bulletin refer to constant speed, alternating current, induction motors, unless other types are specifically mentioned. Practically all of the work is at constant speed: in fact one of the chief advantages in the use of motors is the ability to obtain a uniform speed.

Individual motors are usually used for each machine and device, although frequently it is possible to group the units and drive several with one motor. This usually means a saving in initial cost, but it often increases the maintenance cost for oils and belts and is likely to sacrifice good arrangement of equipment. In addition, group drive has in a small way the same drawbacks as shaft drive of any kind; i. e., the necessity of stopping all units to stop one.

The total horsepower of all the motors required in a Douglas fir saw and planing mill varies from 10 to 13 for each thousand board feet of lumber produced in a 10 hour day, depending upon the type of mill and extent of the planing mill work.

Owing to the intermittent and fluctuating character of sawmill work, the load factors for the different motors vary from 2 per cent to as high as 90 per cent. The average load factor is from 30 to 50 per cent.

The size and weight of the motors used for each of the various machines are given with the description of the machine.

COST OF INSTALLING WIRES AND CONDUITS

The cost of installing the wires and conduits for electric motors and lighting systems vary greatly with the voltage, the style of installation, the length of main and branch conduits, and similar factors. For the purpose of rough estimates the cost can be figured approximately at from 20 to 30 per cent of the total cost of the motors.

POWER COSTS

LABOR

The labor cost for operating the power plant varies from 12 to 21 cents per thousand board feet, depending upon the size of the mill and the wages paid. The average is close to 16 cents. The power cost is frequently prorated to the various departments in proportion to the service rendered each.

REPAIRS

The power plant repair cost for both labor and material ranges from 3 to 12 cents per thousand board feet of lumber cut, depending principally upon the age of the plant. It averages about 5 or 6 cents.

SUPPLIES

The various power plant supplies, such as oil, waste, babbitt, belts, gauge charts, and the like cost from 1 to 3 cents per thousand board feet of lumber cut. Where the oils and belts are charged against the sawmill direct, there is little or no expense for supplies at the power plant.

POWER PLANT INVESTMENTS

Detailed estimates of the complete cost of power installations of typical sizes are given below.

No. 1

Power plant to supply steam to:		
1 500 Kw. high pressure condensing turbine.		
1 dry kiln—200 boiler horsepower.		
1 sawmill—100 boiler horsepower.		
Power house 50 x 48 x 24 feet (24 feet trusses), built of brick, concrete with steel roof		$ 5,000
Turbine room, 25 x 30 x 24 feet (24 feet trusses)		2,000
Boilers, 700 boiler horse power	$9,100	
Stack, sawdust deck, conveyor	2,600	
Brick setting	3,100	
Foundation	700	
Feed water heater	875	
Feed pumps	350	
Piping	1,050	16,775
1 500 Kw., high pressure, 3,600 R. p. m., 3-phase, 60-cycle turbine		10,500
Foundation		600
Exciter:		
Turbo exciter		1,150
Motor generator set		500
Turbine piping condenser equipment circulating pump		2,900
Switchboard		1,500
Power station wiring material		150
Lighting transformers		275
Installation of turbine and condensers, switchboard		1,000
		$43,350

No. 2

Power plant to supply steam to:		
1 1,000 Kw. high pressure condensing turbine.		
1 dry kiln, 200 boiler horsepower.		
1 sawmill, 100 boiler horsepower.		
Power house 50 x 60 x 24 feet, built of brick, concrete, with steel roof		$ 6,000
Turbine room, 25 x 30 x 24 feet		2,000
Boilers, 1,050 horsepower	$13,650	
Stack, sawdust deck, conveyor	3,900	
Brick	3,150	
Foundations	1,050	
Feed water heaters	1,312	
Pump (feed)	525	
Piping	1,575	25,162
1 1,000 Kw., high-pressure turbine, 3-phase, 60-cycle, 3,600 R. p. m.		14,900
Foundation		600
Exciters:		
Turbo exciter		1,200
Motor generator set		625
Turbine piping condenser equipment, circulating pump, etc.		4,500
Switchboard		1,760
Power station, wiring material		200
Lighting transformers		275
Installations of turbine, condenser, switchboard, etc.		1,100
		$58,372

No. 3

Power plant to supply steam to:		
1 2,000 Kw. high pressure condensing turbine.		
1 dry kiln, 200 boiler horsepower.		
1 sawmill, 100 boiler horsepower.		
Power house 50 x 70 x 24 feet, built of concrete, brick, with steel roof		$ 8,500
Turbine room, 25 x 30 x 24 feet		2,000
Boilers, 1,400 horsepower	$18,200	
Stack, sawdust deck, conveyor	5,200	
Brick setting	4,200	
Foundations	1,400	
Feed water heaters	1,725	
Feed pump	700	
Piping	2,100	33,525

1 2,000 Kw. high pressure turbine, 3-phase, 60-cycle, 3,600 R. p. m.	26,400
Foundation	900
Exciters:	
Turbo-generator	1,375
Motor generator set	650
Turbine piping, condensers, circulating pump, etc,	8,500
Switchboard	2,430
Power station wiring material	275
Lighting transformers	275
Installation of turbine, condenser, switchboard	1,500
	$86,330

Note.—The buildings have concrete foundations, brick walls, and steel roof such as are commonly found in up-to-date sawmill installations.

In obtaining costs of boilers, estimates are based on boilers of 350 boiler horsepower capacity.

All estimates on turbines are based on high pressure condensing turbines direct connected to alternating current generators, 3-phase, 60-cycle, 3,600 R. p. m., 550 volts, 8 power factor.

All estimates on condensing equipment are based on the eductor type condensers giving a vacuum from 26 to 28 inches. No dry air or discharge pumps are included.

The switchboard would consist of a bracket mounted voltage regulator double exciter panel,—generator and feeder panel. Only those meters are included which are usually put in for this type of installation.

All costs have been made up on the assumption that the installations would be made at Portland. They have been very conservatively made but would vary over a wide range owing to changes in design, plant layout, foundations, market conditions, and many other variables.

REFUSE BURNERS

The large amount of wood and bark waste produced in reducing logs to lumber makes large incinerators necessary where there is no market for such material in slab or hogged form. Practically all fir mills dispose of some of their waste in this way.

There are several types of waste burners, varying in elaborateness and cost from an open pile or dump to large steel towers lined with brick and equipped with grates to aid combustion and spark screens to reduce the fire hazard. Some of them are equipped with water jackets to reduce the temperature of the shell and to provide hot boiler feed water.

The capacity of these burners depends upon their diameter and the amount of grate area in each. They usually consume about two cubic feet of wood waste per square foot of grate surface per hour. The sizes ordinarily employed are shown in the following tabulation.

SIZE AND COST OF STANDARD BURNERS (1916)
(Steel, brick-lined)

Size of mill, 20-hour capacity	Diameter, ft.	Height, ft.	Cost erected on Pacific coast, $
25,000 to 35,000	14	40	2,000
40,000 to 50,000	16	40	3,500
60,000 to 75,000	20	60	7,500
100,000 to 135,000	28	65	9,000
150,000 to 200,000	30	70	12,000
200,000 to 300,000	34	85	15,000
500,000 to 600,000	40	90	25,000
700,000 to 800,000	65	110	35,000

The above costs are for substantially constructed cylindrical burners. Installations have been made for less. Concrete shell brick-lined burners of the same sizes cost from 40 per cent to 50 per cent less.

A new style of burner has recently (1916) come on the market which costs less than the standard burner of like capacity and appears to give satisfaction. The principle is the same except that the base is made extremely large and air is admitted, so that brick linings or water jackets are not necessary, owing to the great distance between the walls and the burning refuse.

Most burners require the services of a man to regulate the draughts and clean out the ashes. The cost per thousand feet of lumber cut varies from about one cent in large plants to about 5 cents in small ones. At the average plant it is close to 2 cents.

The cost of making repairs, such as replacing grates, relining with brick, or putting on new screens varies with the type and size of burner, the size of the mill, and the amount of work the burner is required to do. The cost per thousand board feet of lumber cut ranges from one cent to six cents. The average is not more than a cent and a half or two cents.

MACHINE AND BLACKSMITH SHOPS

Every lumber manufacturing plant has a blacksmith shop and most of them some kind of a machine shop as well. Usually these are combined in the same building. Their function is to repair broken machinery and equipment, or to make new parts which can be made without elaborate equipment. Proximity to large cities has an important bearing on the size and equipment of repair shops, since those at large mills in isolated regions are required to do much more difficult work than those at the close-in mills where the difficult work can be sent to city machine shops.

The principal pieces of equipment are forges, anvils, engine lathes, pipe threaders, drills, shapers, and planers. The investment in buildings and equipment, including stock used in repair work, varies from $2,000 to $15,000.

FIRE PROTECTION

WATER SUPPLY

Insurance underwriters require that the automatic sprinkler systems in modern sawmills be connected with water supply from at least two sources. Since more than one source is seldom available, it has become common practice to install tower storage tanks as an extra source of water.

The 25,000 to 50,000 gallon tanks are most common at fir mills, although 100,000 gallon tanks are installed at some of the larger plants. The usual practice is to install 8,000 gallons of storage for each 100 sprinkler heads. The tanks are elevated from 25 to 30 feet above the highest sprinkler head to insure sufficient pressure for a good distribution of water from each head. The total height of tank supports is ordinarily from 65 to 85 feet.

The cost of installing these water towers is shown in the following tabulation. The height is the principal factor of cost for a given size.

COST OF WATER TOWERS (1916)

Capacity of tank, gallons	Number of posts,	Size of posts, inches	Installed costs, $
5,000	8	6 x 6	500 - 1,000
10,000	9	8 x 8	1,000 - 1,500
25,000	12	10 x 10	1,500 - 2,000
50,000	12	12 x 12	2,000 - 3,000
100,000	21	12 x 12	3,000 - 3,500

The water mains for sprinkling systems, fire hydrants, boiler feeds, and drinking purposes vary greatly in cost, owing to marked differences in the extent and elaborateness of such installation. The cost at plants where records are available indicate that the investment in pipe lines of this class ranges from $2,000 to $8,000. Distances, size of mains, and number and style of outlets all affect the total cost.

AUTOMATIC SPRINKLERS

Automatic sprinklers are coming into general use in the Douglas fir region and are looked upon as a necessary part of the standard equipment. This is because of the great saving in insurance premiums. The difference in insurance cost is about 50 per cent on the portion of the plant sprinkled.

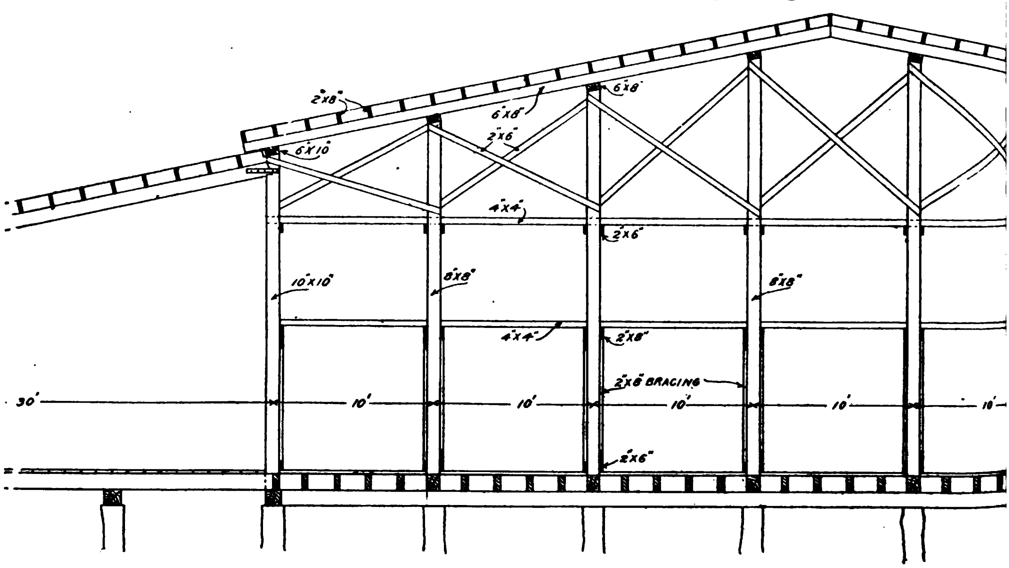


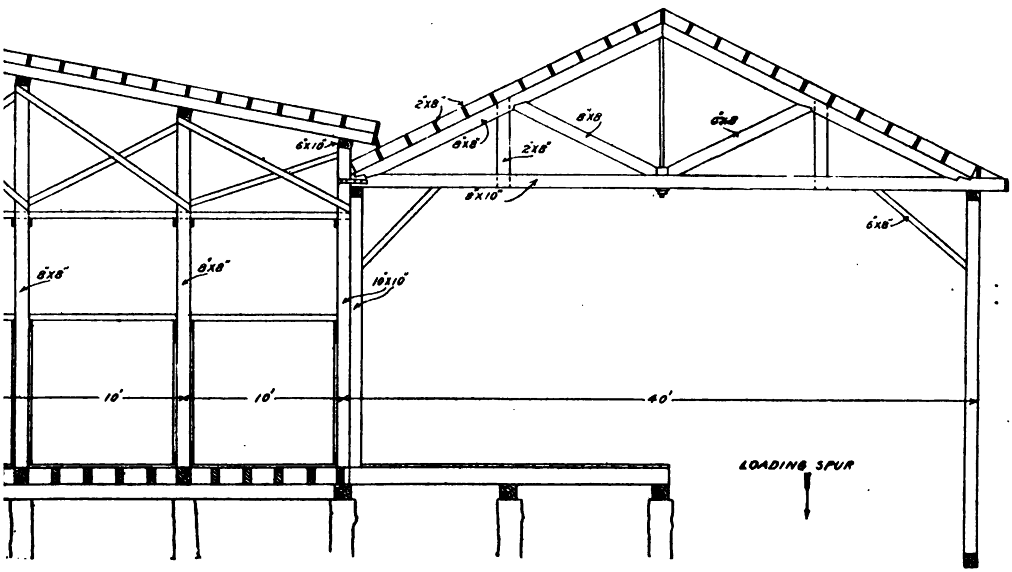
Fig. 53. End elevation of dressed lumb

Detailed and specific instructions for installing sprinkling systems may be obtained from the National Board of Fire Underwriters, from whose regulations (1916) were obtained the data here presented, which are offered to illustrate the effect of design upon cost.

There are two types of automatic sprinklers in common use, i. e., wet and dry. In the first type all the main and branch pipe lines are constantly filled with water, under pressure. This type can not be used in the Northwest because of the possibility of freezing. The dry type, which is adapted to use in Douglas fir mills, is usually operated as a wet system during the summer months and a dry system in the winter. In the dry system the branch pipes (subject to freezing) are filled with air and no water is admitted to them except by an automatic valve, which operates only when the air is released by the opening of one or more of the sprinkler heads.

The automatic sprinkler heads are set off by the action of heat, which causes the alloy plugs or stoppers to melt. The temperatures at which the various heads now in general use are melted are as follows: 155°, 165°, 212°, 286°, and 360° F. Those melting at low temperatures are most desirable and are generally used because they respond quickly after a fire is started. They cannot be used, however, in dry kilns and similar places where temperatures in excess of 165° are common or are likely to be reached. The higher temperature heads, 286°, or 360°, are used in the dry kilns, since even the 212° heads might be released by unusual conditions in kilns ordinarily using temperatures considerably lower than 212°.

In general, the distance between sprinkler heads does not exceed eight feet when measured at right angles to floor and roof joists and 10 feet parallel to them. These are maximum distances for so-called uninterrupted areas. Since the girders on beams which support the joists (except when joists hangers are used) form barriers or partitions, the actual average number of square feet per sprinkler is always less than the maximum unless the girders are spaced on 10 feet (or multiples of 10 feet) centers. Furthermore, the sprinklers are staggered and the end heads on alternate lines are not more than two feet from walls or partitions. In general, from 65 to 70 square feet is served by the average sprinkler.



ied designed for storing lumber on end.

Different sizes of pipe are used according to the number of sprinkler heads supplied by the branch.

SIZES OF PIPE FOR AUTOMATIC SPRINKLERS

Size of pipe, in.	Number of heads,	Size of pipe, in.	Number of heads
¾	1	3	36
1	2	3½	55
1¼	3	4	80
1½	5	5	140
2	10	6	200
2½	20		

Where practicable, not more than eight heads are placed on one branch line.

The maximum number of sprinklers permitted on one dry valve is 500, while the recommended number is 300. This is to insure rapid exhaustion of air and quick delivery of water in case of fire.

Automatic sprinkling systems, exclusive of the water and air supply systems but including all necessary valves, gauges, etc., cost approximately as follows for mills of representative sizes:

Size of mill, 10-hour cut, bd. ft.	Cost of sprinkler installed, (1916), $
35,000	3.500
75,000	5,000
100,000	7,500
150,000	12,000
200,000	15,000

Rough estimates may also be obtained by calculating the cost at $6 per sprinkler head.

CHEMICAL TRUCKS AND EXTINGUISHERS

At many Douglas fir mills small chemical fire trucks which may be hauled by hand are placed at convenient points around the yard. They are made in two sizes, 25 gallons and 40 gallons. Each has a 50 foot hose and will throw a 50 foot stream, giving a working radius of 100 feet. The two sizes cost $165 and $185 respectively (1916).

There are several types of hand fire extinguishers, their efficiency varying with their cost. From fifteen to twenty-five of these are ordinarily placed about an average plant. They cost about as follows:

COST OF HAND FIRE EXTINGUISHERS (1916)

Form	Size	Cost
Powder in tube	20 inches	$ 1.00
Powder in tube	12 inches	.75
Chemical	1 quart	8.00
Soda	3 gallons	12.00

WAGES OF MILL OPERATIVES (1912-1915)

The wages of the operatives in Douglas fir mills range from $2 to $12 per day. The wage for a given occupation depends upon the character and amount of work, the dexterity and judgment of the operative, and the scale or level of wages in effect at the time. All of these variables are covered in the range between the high and low figures in the following list. If used with judgment, these figures serve as a guide to daily plant costs for mills of given size and equipment.

WAGES

Worker	Daily wages		
	High	Medium	Low
Pond:			
Pondman or boomman	$3.25	$2.75	$2.50
Helpers	2.75	2.50	2.25
Sawmill:			
Foreman	6.00	5.00	4.00
Log hoist tender	3.00	2.75	2.50
Deckman	2.75	2.50	2.00
Scaler	3.00	2.75	2.50
Rock sawyer	2.25	2.00	1.75
Setterman	3.75	3.50	3.00
Doggers	2.75	2.50	2.25
Head sawyer (band)	8.00	6.50	5.00
Head sawyer (circular)	6.00	5.00	4.00
Tail sawyer (offbearer)	2.75	2.50	2.25
Edgerman	4.75	4.00	3.50
Edger helpers	2.75	2.50	2.25
Slasherman	2.50	2.25	2.00
Trimmerman	4.00	3.75	3.50
Trimmer helpers	2.75	2.50	2.25
Timber trimmerman	3.00	2.75	2.50
Filer (band)	12.00	10.00	9.00
Filer (circular)	6.00	5.00	4.00
Filer helpers	3.50	3.00	2.75
Millwright	5.00	4.50	4.00
Millwright helpers	3.75	3.50	3.25
Oiler	3.00	2.75	2.50
Clean-up man	2.50	2.25	2.00
Remanufacturing department:			
Resawyer (Roller)	4.00	3.75	3.50
Resawyer (Gang)	3.75	3.50	3.00
Helpers	2.75	2.50	2.25
Re-edgerman	3.00	2.75	2.50
Re-trimmerman	3.00	2.75	2.50
Grading and sorting tables:			
Grader	4.00	3.50	3.00
Grader's helper	2.75	2.50	2.25
Tallyman	3.75	3.50	3.25
Sorting men	2.50	2.25	2.00
Trucking and transporting:			
Teamsters	3.00	2.75	2.50
Tractor drivers	3.25	3.00	2.75
Monorail operative	4.50	3.25	3.00
Monorail helpers	2.75	2.50	2.25
Truck chaser	2.50	2.25	2.00
Truck mender	3.50	3.25	3.00
Locomotive crane engineer	4.50	3.50	3.00
Locomotive crane fireman	3.00	2.75	2.50
Hook tenders	3.00	2.75	2.50
Kiln drying:			
Kiln tender	3.00	2.75	2.50
Pilers	3.00	2.75	2.50
Unpilers	2.75	2.50	2.25
Marker or grader (Kiln stock)	3.00	2.75	2.50
Sorting men	2.50	2.25	2.00
Seasoning and storage yard:			
Foreman	5.00	4.50	4.00
Pilers	3.00	2.75	2.50
Unpilers	3.00	2.75	2.50
Graders	4.50	4.00	3.00
Tallymen	3.00	2.75	2.50

Planing mill:			
Foreman	4.50	4.00	3.75
Feedermen	2.75	2.50	2.25
Tailers	2.75	2.50	2.25
Bundlers	2.50	2.25	2.00
Pneumatic trimmermen	3.75	3.50	3.00
Grader	3.25	3.00	2.75
Sortermen	2.50	2.25	2.00
Filer and grinder	6.00	5.00	4.00
Grinding room helper	3.00	2.75	2.50
Ripsawyer	3.00	2.75	2.50
Ripsaw helper	2.50	2.25	2.00
Lumber sheds and loading platforms:			
Foreman	5.00	4.50	4.00
Stackers	2.75	2.50	2.25
Unstackers	2.75	2.50	2.25
Car loaders	2.75	2.50	2.25
Graders and tallymen	3.50	3.25	3.00
Power house:			
Chief engineer (Steam)	4.50	4.00	3.50
Chief engineer (Electrical)	6.00	5.00	4.50
Assistant engineer	3.25	2.75	2.50
Day fireman	3.25	3.00	2.75
Night fireman	3.00	2.75	2.50
Blacksmith and machine shops:			
Blacksmith	4.00	3.75	3.50
Blacksmith helper	2.75	2.50	2.25
Machinist	4.50	4.00	3.75
Machinist helper	3.00	2.75	2.50

MONTHLY SALARY

	Office force		
Monthly salary	High	Medium	Low
Manager[1]	$800.00	$500.00	$300.00
Superintendent	250.00	200.00	150.00
Sales manager	250.00	200.00	150.00
Secretary-treasurer[1]	200.00	175.00	150.00
Book-keeper	125.00	100.00	80.00
Time-keeper	90.00	75.00	60.00
Stenographer[1]	75.00	50.00	40.00
Shipping clerk	100.00	90.00	75.00
Night watchman	90.00	85.00	75.00
Messenger boy[1]	35.00	30.00	25.00

[1] Part of the time of these men is sometimes chargeable to logging.

TAXES

PROPERTY TAX

The general property tax laws applicable to lumber manufacturing plants in Oregon and Washington are essentialy the same as those of other states. The real and personal property is annually assessed at from 40 to 50 per cent of its value and the tax levies made on this basis. Payments are due semi-annually, in the spring and fall of the year succeeding the one to which the assessment applies.

The annual tax on sawmills is extremely variable for plants of like capacity, primarily because of differences in the levies but also because of differences in site of values and other investments. The variation in levies is in turn due to the revenues raised in the different counties and to special levies of towns and large cities. In the following table are given typical levies for urban, suburban, and rural properties. They include State, county, municipal, and school taxes.

TYPICAL TOTAL TAX LEVIES IN THE DOUGLAS FIR REGION

Location of property	Total tax levy in mills		
	High	Medium	Low
Urban	50	30	20
Suburban	40	25	18
Rural	25	20	15

In addition to the general property tax, there are numerous minor assessments, such as corporation taxes, factory and boiler inspection fees, auto licenses, and similar annual charges; but these do not amount to much.

The amount of the Federal income tax varies so much from year to year that it is impossible to give any idea of its cost per thousand board feet or similar unit. It should not be overlooked, however, in calculating the net profit on lumber manufacturing operations.

TAX COSTS PER THOUSAND BOARD FEET

The total tax per thousand feet of lumber produced is even more variable from mill to mill than the levy. It differs through variations in site and plant investments per thousand feet of cut and through differences in the average quantities of logs and lumber on hand in proportion to the annual cut. The following table is given as a guide in estimating total taxes for average mills having on hand normal log and lumber supplies. The figures include all taxes except the income tax and are based on constant operation of the plant. Where plants are not or cannot be operated throughout the year, the costs should be increased in proper proportion. Increases should also be made for abnormal investments in sites, plant, logs, or lumber, or for abnormal county tax levies.

TYPICAL TOTAL TAX COSTS PER THOUSAND BOARD FEET OF LUMBER PRODUCED

Location of plant	Tax costs in cents per thousand feet of cut		
	High	Medium	Low
Urban	12	8	5
Suburban	9	6	4
Rural	6	5	3

INSURANCE

FIRE

The following table gives the rates of fire insurance on Douglas fir mills which are not equipped with sprinkling systems.

RATES ON DOUGLAS FIR MILLS
(Unsprinkled)

Class	Rates per $100.00 Low	Medium	High
Sawmill building and equipment	$2.50	$3.00	$5.00
Dry-kiln building	[1] 2.50	...	[2] 4.00
Dry-kiln contents	3.00	...	4.50
Dry sheds and stock	1.50	2.00	3.00
Yard stock	1.50	2.00	3.00

[1] Brick, tile, or concrete. [2] Wood.

In the table the insurance is based on $3.00 per hundred dollars of valuation as a standard, and increased or decreased from this amount according to the risk.

Douglas fir mills receive insurance at 25 cents less than western red cedar or inland pine mills because of the less inflammable character of the mill dust and the humid atmosphere in the region.

The usual distance required between yard and adjoining buildings is 200 feet. From twenty to twenty-five cents is added for each 50 feet less than the required distance. For distances 50 feet or less, the rate is the same as that on the exposure, or adjoining property. Distances greater than 200 feet take the 200 foot rate.

Sprinkling systems, with two sources of water, reduce the rate from 33 to 50 per cent, depending upon the construction of the frame. Open frame buildings receive less reduction because of drafts. Mills having only one source of water for sprinkling obtain only a 25 per cent reduction over unsprinkled rates.

Mills located inside of city limits gain from 25 to 40 cents per hundred, depending upon the nearness and type of city fire fighting equipment.

Electric drive in sprinkled mills reduces the rate from 20 to 25 cents, and in unsprinkled mills from 40 to 50 cents.

Mills having a night watchman and clock get a reduction of 50 cents, while those having a watchman without clock gain only 25 cents.

Mills cutting "dry" logs (operating without log pond) are assessed $1.00 more because of increased dust and dryer condition of the plant.

Reliable companies, with sprinkled mills, can insure their plant at 100 per cent of the value and the stock at two-thirds of its value.

Sprinkled mills must carry at least 70 per cent insurance in order to protect the insurance companies by allowing them a reasonable premium. Nonsprinkled mills are not allowed to carry more than two-thirds to three-fourths of the value of their plant.

The lowest probable rate on a Douglas fir mill would be in the neighborhood of 70 or 80 cents.

The actual cost of fire insurance per thousand board feet of lumber cut ranges from 8 to 25 cents. The average cost is close to 15 cents.

LIABILITY

The cost of liability insurance per thousand feet of lumber produced ranges from 6 to 12 cents, depending upon the character of the lumber product (i. e. how much labor it requires). The average is close to 9 cents.

COST SEGREGATIONS

The methods of segregating the various items included in the total cost of producing Douglas fir products are not uniform among the operators. This has made it extremely difficult to obtain reliable figures of cost and to compare the costs at one plant with those at another.

The following segregations are designed to make it possible to obtain the detailed costs of producing each thousand board feet of the various classes of lumber, such as rough, dressed, green, kiln dried, and air dried, and to compare the relative efficiency of operatives, equipment, and transportation. They will also serve as a guide in quoting on orders.

An endeavor has been made to arrange the segregation in such a way that the individual items of cost can be combined to form the same major groups as those used by the mills which do not carry out refined accounting.

At most plants, the yard account is a "catchall" to which many miscellaneous expenses are charged. From the standpoint of accurate cost segregating, the usual yard items may be separated as follows: transportation, shipping, air-drying, dry sheds, docks, and platforms. These segregations are needed in determining the cost of handling any class of product which is not subject to all of the costs which in the past have been charged to yard expense.

(1) Boom: The boom expense includes labor, repairs, and supplies necessary to keep the boom in operation for lumber manufacture. It does not include expense which assists in the delivery of the logs to the boom, in cutting the logs to length, or scaling for camp or buying records, since these are charged preferably to the cost of the logs. Boom expense delivers the logs to the log slip.

(2) Sawmill: The sawmill account includes all items of expense in sawing rough lumber. Timber surfacing and sizing, conducted at the sawmill or on the sorting chains, are charged to surfacing and included in the planing mill account. Any resawing and ripping of rough lumber in other departments may be charged to the saw mill account or kept as a separate item.

(3) Sorting: Sorting includes grading at the sorting chains and pulling lumber off them, and placing it on trucks or in units for transportation to the various departments. Where lumber is loaded directly from the chains upon dry-kiln trucks or upon cars for shipment, the expense for handling is charged to kiln-drying or shipping respectively. If lumber is "stuck" at the chains for air-drying, a portion of the sorting cost is charged to air-drying, (piling).

(4) Surfacing and matching: The surfacing and matching account includes all planing mill charges and, as mentioned above, the cost of operating and maintaining any timber surfacers and sizers at the sawmill. It takes the lumber from the trucks at the machine and replaces it dressed, graded, and bundled, if necessary, upon trucks for delivery to the shed or cars.

Where accurate costs of these items for each class of product are desired, it is the practice to separate kiln-dried lumber which has to be graded and bundled from other dressed lumber, since there is a marked difference in the cost.

(5) Kiln-drying: The dry-kiln account covers all expense necessary in preparing the lumber for the kilns and, after drying, putting it in shape for transportation to the next department. Supply and repair items incident to kiln-drying are charged to this account. At some plants care is taken to see that lumber used for stickers and bunks is credited to the lumber account and charged to the kiln account.

(6) Trucking or transportation: All movement of lumber from one department to another is considered as a separate account, in order to permit proper distribution of this important expense among the various classes of product. Transportation includes wages of teamsters, truck rustlers, and tractor drivers. The maintaining of roadways, tracks, and equipment is included and shown distinctly. Barn expense and other items entering into the cost of delivering the product from one part of the plant to another also are charged to this account.

Any portion of the barn expense which may be charged properly to the delivery of retail lumber or wood is charged to such accounts. Where monorail hoists, cranes, or other trucking devices are used in piling or loading lumber, a proper portion of the cost is charged to such operations.

(7) Air-drying: Air-drying includes taking the lumber from platforms or trucks, piling it properly for air-seasoning, and unpiling it for shipment. The unpiling for shipment is sometimes considered as part of the cost of shipping. Any final grading for shipment during the process of taking down, is charged to shipping. The cost of lumber used for cross pieces or stickers, pile covers, and drip boards, and other expenses necessary in maintaining the seasoning yard are charged to this account. Where lumber is "stuck" at the chains, a proper portion of the cost of sorting is charged to air-drying. Also when piling is done by monorail or crane, "air-drying" is charged with a portion of the transportation item. Any sorting necessary in the yard because of incomplete segregation on the chains is carried as a separate item or charged to sorting. It is not strictly an air-drying cost.

(8) Dry shed: The dry shed account includes all expense incident to stacking lumber from the trucks or floor and taking it down for shipment. The unpiling for shipment is sometimes considered as part of the cost of shipping. Any grading which is done in the dry shed, preparatory to shipment, is charged to "shipping." Trimming, grading, and bundling of dressed stock in the shed are charged to "surfacing."

Where rough dry lumber is stored in sheds before surfacing or shipment, this operation is usually treated as a separate shed account instead of being grouped with the dressed shed costs.

(9) Shipping: Shipping includes tallying, grading, loading, demurrage, shipping clerk's salary, and other expense necessary to prepare the lumber for shipment. It sometimes includes expense in taking down lumber in the yard or shed, and picking up lumber in the planing mill for direct shipment.

It is frequently desirable to segregate loading upon cars from loading upon scows.

It will be seen that the various items relating to the cost of preparing lumber for shipment have been treated as part of the cost of production. Some authorities rightly feel that this is not a part of the cost of production and that it should be treated as a separate cost, like selling.

(10) Docks and platforms: Expenses in maintaining the docks and platforms, handling lumber on them, and rehandling of any kind which cannot be charged to any of the above items, are included in the dock and platform account. It may be desirable at certain plants to separate dock expense from platform expense, where lumber is handled for both rail and water shipment. Where timbers and other forms are "stuck" on the platforms for "air seasoning" the extra cost may be charged to air-seasoning.

(11) Power: The expense of operating and maintaining the boiler house, fuel house, and engine room is charged to power.

The total expense for power, except plant items, is prorated to the various departments, including the kilns, in proportion to the horsepower or a similar unit of service rendered each.

Net receipts for light or power sold to outside parties may be credited to the power plant before the monthly prorating, or they may be treated as receipts for by-products and handled in the same manner as the wood or lath items.

(12) Blacksmith and machine shop: The blacksmith and machine shop are usually self-supporting. Expense in operating and maintaining them is charged to the various other departments. The idle time is prorated in proportion to the time employed in work for each department. Some mills carry the machine and blacksmith shop as a separate plant and charge for such work as an outside shop would do. If there is a profit or loss at the end of the year, it is prorated to each item previously charged before the books are closed.

In the case of the larger plants, the following segregations are usually chargeable to several or all of the operating departments in proportion to the service rendered. These segregations are used in order to insure proportionate charges for each of these classes of service to the various operations. The percentage of most of these segregations usually remains constant, so that after it has been once determined the bookkeeper prorates it without further consultation until changes are made.

(13) Steam mains.

(14) Water mains (including sprinkler system).

(15) Fire fighting equipment.

(16) Blower system.

(17) Electrical wiring and conduits. Electricity is included in power.

(18) Fire insurance.

(19) Industrial insurance.

(20) Site.

(21) Taxes.

(22) Oils and grease: Oils, grease, gasoline, and other similar products which are purchased in large quantities and used by the various departments are usually placed in a separate account and charged to each on a requisition basis.

(23) Burner: The burner is properly part of the sawmill equipment, but it is usually desirable to keep this expense separate in order to determine the cost of destroying waste and thus permit calculating the relative value of various methods of waste utilization or disposal.

(24) Wood: Both expenses and receipts for wood sold are usually entered on the wood account. This includes millwright expense, power, barn, and a portion of other items which are necessary to the manufacture and disposal of wood. The monthly or annual net gain on this account may be transferred to profit and loss. Hogged fuel which is sold is treated in the same manner.

(25) Lath: Both expense and receipts for lath are usually entered on the lath account. This should include millwright expense, power, and a portion of other items which are necessary to the manufacture of lath. The monthly or annual net gain on this account may be transferred to profit and loss.

(26) Office: All salaries and office expense incident to lumber manufacture may be charged to the office account. This item also includes sundry expenses for supplies, postage, telephone, telegraph and the like. It is very seldom practicable to prorate the office expense to the various departments.

The total cost of each of the segregations is logically divided into the six following classes of expense: (1) operation—labor, (2) operation—

supplies, (3) repairs—labor, (4) repairs—materials, (5) plant—labor, (6) plant—materials and equipment. The last two (5 and 6) are included to cover the construction accounts at new plants and improvement and replacements at old plants. It seems desirable to separate supplies from repairs so as to determine the relative repair costs at large and small and old and new mills and the relative supply costs at electric and steam mills.

Operation—labor includes all expense for labor and supervision needed to keep the plant in constant operation, barring accident. It includes expense for filers, oilers, foremen, night watchmen and all outside men, as well as part of the time of any office men who have charge of outside work. The timekeeper is considered an office man. When operatives in any of the departments spend part of their time in repair work, such as repairing their own machines, the expense may properly be charged to repairs. The amount is ascertained by requiring the timekeeper to report the number of hours spent by each man on this kind of work.

Operation—supplies includes expenditures for yarn, saws, saw teeth, files, emeries, and similar expendable material. A list of such supplies is given below to aid in a uniform classification.

Babbitt, belts, band saws, belt laces, binder wire, books, brooms, cable carbon papers, car stakes, chalk, charcoal, circular saws, clips, clock charts coal, crayon, drills, emeries, files, forms, fuel oil, fuses, gaskets, gasoline, gauge charts, grease, horse feed, horse medicine, horseshoes, horseshoe nails, ink, kiln car bunks (wooden), knives, light bulbs, lumber (car stakes, stickers, etc., see also repairs), oils, packing, pencils, pens, pins, pipe lead, rope, rubber stamps, saws (band and circular), saw teeth, stationery, stickers, tractor batteries, tractor tires, tally cards, typewriter ribbons, washers (rubber, etc.), waste, yarn.

Supply items, such as oils and greases, which are purchased in large quantities for the use of all departments, are usually carried as a separate account, and prorated to the various departments by means of requisitions or other accurate records of distribution.

Repairs—labor includes all labor used in making repairs except machine shop and blacksmith shop labor, which is ordinarily charged to the material furnished or repaired. Some mills include the millwrights' wages in the repair labor account, and prorate their time to each department, on this basis of the time employed in each. This appears to be good practice.

Repairs—material covers both material that is bought and material obtained from the company's shops, which is charged to this account at cost. For convenience, it may be desirable to charge labor employed in the blacksmith or machine shop to this account, and thus make it comparable to repairs made by outside parties when the labor for the repairs cannot be distinguished from the material. The following articles may be charged to repairs.

Bar iron, bolts, boxes, chains, chain belts, collars, cutter heads, fire brick, fire hose, gauges, grate bars, grease cups, harness, instruments, lumber (other than stickers, bunks, etc.), machinery parts, metal washers, nails, nuts, oil cans, paint, pipe, pipe fittings, pulleys, rails, railroad spikes, roofing, screws, shafting, sheet iron, sprinkler heads, sprockets, spurs and gears, tools, valves.

It is frequently advisable to distinguish between ordinary repairs and large replacements. Ordinary repairs are usually charged directly to the repair account, while large replacements or improvements which would affect abnormally the repair account for a given period are so handled as to afford an equitable distribution of their cost over different periods.

Where this is not effected by means of a depreciation or sinking fund account, consistently maintained, to which the large replacement or improvements are charged, that portion of the expense for large replacements

or improvements which increases the depreciated value of any permanent part of the plant is usually charged to the plant or investment account. The rest, or the depreciated value of the property replaced, is charged to operation, either in the repair account or, preferably, in a separate account, to be prorated as before mentioned. Receipts for junk or equipment sold are credited to the same account.

The substitution of modern equipment for obsolete equipment may be handled in the same manner, but, as mentioned above, where the item is large enough to have an appreciable effect on the repair costs it is usually charged to a separate account, and the cost spread over a considerable period.

Plant—labor may be charged with all expense for labor used in construction or the portion used to increase the depreciated value of the plant, in making repairs, improvements, or replacements, as mentioned above, these being considered as an increase in investment.

Plant—materials and equipment may be charged with all expense for construction material and additional equipment, as well as the portion of the expense which increases the depreciated value of the plant in making repairs.

These expenses in the plant account, both in original and subsequent construction or installation, are itemized as far as possible to permit proper subsequent distribution of depreciation.

PLANT INVESTMENT SUMMARIES

The following estimates were compiled as a reference for making approximate calculations of the total investment in lumber manufacturing plants. The range in the amount for specific items is designed to take care of the various factors which affect each item, such as capacity of plant, type and size of each unit, and method employed in the operation. Accuracy is not claimed for such figures; but, where properly used, they should serve as a guide to the cost of an existing or proposed installation. The figures represent costs per board foot of daily (10 hr.) production. Those for the various departments, such as dry kiln, planing mill, etc., are based on the quantity of material daily put through each of these departments or steps in the operation instead of the total daily lumber cut in the sawmill proper.

SUMMARY OF PLANT INVESTMENTS

(In cents per board foot of 10 hr. cut effective 1912-1915)

	Item	High, cents	Intermediate, cents	Low, cents
1.	Engineering	5.0	3.0	1.0
2.	Site (including clearing and fills)	100.0	25.0	6.0
3.	Pond (additional to site cost)	20.0	6.0	3.0
4.	Sawmill Building (including foundations)	15.0	12.5	10.0
5.	Sawmill Annex (for resaws etc.)	5.0	3.0	1.0
6.	Machinery for 4 and 5 Installed	60.0	50.0	30.0
7.	Motors (or shafting and pulleys) for Sawmill	15.0	10.0	8.0
8.	File Room Equipment Installed	3.0	1.5	0.1
9.	Belts for Sawmill	5.0	4.0	2.0
10.	Saws	3.0	1.5	0.3
11.	Sorting Table	5.0	3.0	2.0
12.	Sorting Table Shed	.6	.5	.2
13.	Timber Sizer—Rolls and Transfers	.7	.6	.3
14.	Timber Sizer—Building and Substructure	.2	.1	.1
15.	Timber Distributing Rolls and Storage Skids	3.0	1.5	.5
16.	Timber Loading Spur	2.0	1.0	.5
17.	Tramways and Platforms(Except yard)	8.0	5.0	3.0
18.	Cargo Docks (If cargo mill)	15.0	10.0	8.0
19.	Trucks	4.0	3.0	2.0
20.	Horses	4.0	3.0	2.0
21.	Tractors (If used in place of horses)	3.0	2.0	0.5
22.	Monorails[1]	20.0	18.0	15.0
23.	Overhead Crane[1] (For loading, etc.)	10.0	7.0	5.0
24.	Dry Kiln Buildings and All Equipment[1]	40.0	24.0	12.0
25.	Dry Kiln Cooling Sheds[1]	3.0	1.5	1.0
26.	Dry Lumber Sorting Table and Sheds[1]	8.0	5.0	1.0
27.	Tramways to and in Yard[1]	14.0	12.0	5.0
28.	Lumber Pile Foundations[1]	2.0	1.0	0.5
29.	Rough Lumber Shed[1]	4.0	3.0	2.0
30.	Planing Mill Building[1]	5.0	3.0	1.0
31.	Planing Mill Equipment[1]	15.0	12.0	8.0
32.	Motors for Planing Mill[1]	7.0	6.0	4.0
33.	Blower System	3.0	2.0	1.0
34.	Dressed Lumber Shed[1]	8.0	4.0	1.0
35.	Main Loading Spur	4.0	2.0	0.5
36.	Power House—Building	8.0	6.0	3.0
37.	Boilers, etc. Installed	25.0	18.0	12.0
38.	Engines or Turbines Installed	28.0	20.0	9.0
39.	Lighting Equipment }	8.0	5.0	2.0
40.	Electric Motor Wiring }			
41.	Water System	6.0	5.0	2.0
42.	Steam Mains	3.0	2.0	0.5
43.	Sprinkling System, etc.	10.0	8.0	5.0
44.	Machine and Blacksmith Shop	7.0	4.0	2.0
45.	Burner	12.0	8.0	1.0
46.	Office and Equipment	3.0	2.0	1.0
47.	Supplies and Repair parts	10.0	8.0	3.0
48.	Log supply	30.0	18.0	6.0
49.	Lumber stock	100.0	90.0	30.0
50.	Bills receivable	95.0	75.0	10.0
51.	Bank balance	10.0	5.0	3.0

[1] These items are based upon the amount put through the specific department or operation and not upon the total production.

DEPRECIATION

Depreciation is the shrinkage in the value of fixed investments. In a lumber manufacturing plant it may be due to wear and tear, deterioration through rust or other factors affecting its physical condition, or to the exhaustion of available timber supplies.

Methods of calculating depreciation are not uniform among operators or accountants either as to the per cent to be written off annually or the rate to be applied to various kinds of improvements and equipment.

The economic life of any portion of a plant of course depends upon specific conditions, but the low and high rates of depreciation shown below should cover conditions where the material receives reasonable care and is abandoned at the expiration of its natural life.

DEPRECIATION

Investment	Per cent of annual depreciation Low	High
Buildings	5	10
Machinery	7	12
Transmission	5	10
Boilers	10	15
Engines	5	12

In Forest Service timber appraisals the usual practice is to establish an anticipated wrecking or residual value for the various types of investment at the expiration of the cutting period and to distribute the difference between the initial cost and the anticipated value equally over the term or upon each thousand feet of logs cut.

The amount chargeable to each thousand board feet of lumber produced varies from about 25 or 30 cents in simple or long lived well maintained plants to as high as 70 or 80 cents in short lived operations or plants having a relatively high investment per thousand feet of lumber produced. The practice at many plants in the fir region is to place the amount arbitrarily at 50 cents per thousand feet without attempting to arrive at an accurate estimate by careful calculation. Such practice is obviously wrong, but it is better than absolutely disregarding depreciation as is sometimes done.

WORKING CAPITAL

INTRODUCTION

Working capital is the money which an operator must employ (in excess of his fixed investments) to meet current operating expenses and to cover funds tied up in logs, lumber stocks, mill supplies and repair parts, bills receivable, and a bank balance. It sometimes equals or exceeds the amount of the fixed investments, and for this reason is a more important factor in lumber manufacture than is usually supposed.

Working capital is one of the most difficult items of lumber manufacturing to cover in a treatise of this kind, first, because of the wide differences in fir manufacturing and sales practice, and, second, because of the various methods of arriving at the amount of money involved at any one time, or as an average for the year.

These two conditions make it necessary to limit the following discussion to the factors to be considered and the amounts involved in rather normal operations in the fir region. They also indicate the necessity for over conservatism in estimating the amount to be required in a proposed operation, because of inability to predict within reasonable limits the character of product (per cent kiln dried, air seasoned, etc.), the condition and character of market to be met, terms of sale necessary, and the extent of discounting outstanding credits at the bank. The inclination to hold excessive stocks for speculative purposes, however, need not be considered when they are held under normal conditions in anticipation of an abnormal demand which is purely speculative. Holding to meet normal seasonal market changes would not fall in this class.

FACTORS AFFECTING WORKING CAPITAL

LOG SUPPLY

The quantity and cost of logs held in reserve in the log pond, booms, etc., is the first item of the operation which has a bearing on the working capital. The normal log supply at fir mills is usually sufficient to last the mill a month, although at mills doing their own logging or located convenient to large log markets, where logs are obtained on contract from a large and competent operator or several operators, the normal supply may be reduced to the needs for a single week. Where logging is not carried on continuously throughout the year, the computed average supply chargeable to working capital will be nearer the demands for two to four months.

With logs at $7.00 per thousand (mill tally) and figuring that on the average a month's supply is kept on hand at all times, the working capital would amount to 17.5 cents per board foot of daily capacity, or $175 per thousand feet of daily capacity. Obviously, a mill doing its own logging has less invested in logs than one buying logs and paying cash, because the logs are figured at cost in both cases. But many log buying mills have no investment in a log supply, for logs are often cut and shipped before payment is made.

STOCKS ON HAND

The character and amount of lumber in the yard and sheds are probably the greatest factors affecting working capital to be considered. The amount varies with the market and season of the year, because of differences in the time required to reach the desired shipping weight; and the character depends upon the class of logs, kind of trade catered to, kiln drying and air seasoning practice, and ability of the sales department to move the various undesirable grades and sizes produced in connection with sawing the product for which there is a normal demand.

Representative rail shipping mills usually have about 25% of their annual cut in the yard or the equivalent of three months' cut. Those catering to yard trade primarily and cutting only a few structural timbers and ties, and those shipping green by rail or cargo will often have only a few weeks cut on hand. Assuming that the average cost of the lumber in the yard is $12 per thousand board feet and that there is an average of three months' cut on hand at all times, the working capital would amount to 90 cents per board foot of daily capacity, or $900 per thousand board feet of daily capacity.

Mills selling most of their product to the cargo trade will ordinarily have on hand ten to fifteen per cent of their annual cut, while those selling mostly in rail markets have as much as thirty-five to fifty per cent in storage, principally to obtain the "underweights."

SUPPLIES AND REPAIR PARTS

The amount of working capital invested in supplies, such as extra belts, lubricants, babbitts, etc., and small machinery repair parts, such as chain links, sprockets, pulleys, shafting, kiln pipe and fittings, etc., varies greatly with the kind of mill, i. e., character of product, relative size of planing mill, dry kilns, and kind of handling equipment.

Figuring that the supplies and duplicate parts are equivalent to the average requirements for six months, the working capital required would be about eight cents per board foot daily capacity, or eighty dollars per thousand board feet of daily capacity. It is believed that these figures are more or less typical of the average fir mill.

It should be borne in mind that large mills have proportionately less invested in supplies and certain standard repair parts in proportion to their cut than small mills.

BILLS RECEIVABLE

The amount of outstanding money depends primarily on the terms of sale, the tendency to discount railroad bills of lading, the percentage of cash and foreign (usually cash) business and similar factors, and because of these various conditions it is good practice to be exceedingly conservative in estimating the working capital required for this item.

Figuring an average of two months cut represented in the bills receivable account and lumber valued at an average of $15.00 per thousand board feet, the working capital required would amount to 75 cents per board foot of daily production, or $750 per thousand board feet of daily production.

In view of the fact that interest is lost on bills of lading discounted at the bank, and that the transaction is the same as borrowing money, tendency to discount should not be considered as actually reducing the amount required for working capital, but rather as reducing the actual outstanding funds.

The element of time which elapses between the shipment of the product and receipt of payment is one of the greatest variables requiring consideration. It depends principally upon the nature of the buyer. While there are many exceptions to the practices given below, they represent the policy in most of the transactions.

1. Foreign buyers pay cash for the cargos of off-shore lumber shipments as soon as the boat is loaded.

2. Most wholesalers and western lumber brokers either pay cash for their lumber or at least take advantage of the discount allowed for payment within fifteen days of the date of invoice.

3. Middle western and eastern purchasers who buy their lumber direct from the mills take from 15 to 90 days, or even longer, to pay for their purchases. The average period is probably 30 days.

4. The average shipment of lumber to California by water is paid for in 15 days, although the practice is not uniform.

BANK BALANCE

The bank balance carried by most fir mill operators is exceedingly small on the average, seldom exceeding a few thousand dollars more than the amount required to meet the pay roll; and since, from an accounting standpoint, the labor is performed before it is paid for and the payroll is covered by the working capital required for the stock on hand, this latter money may be disregarded.

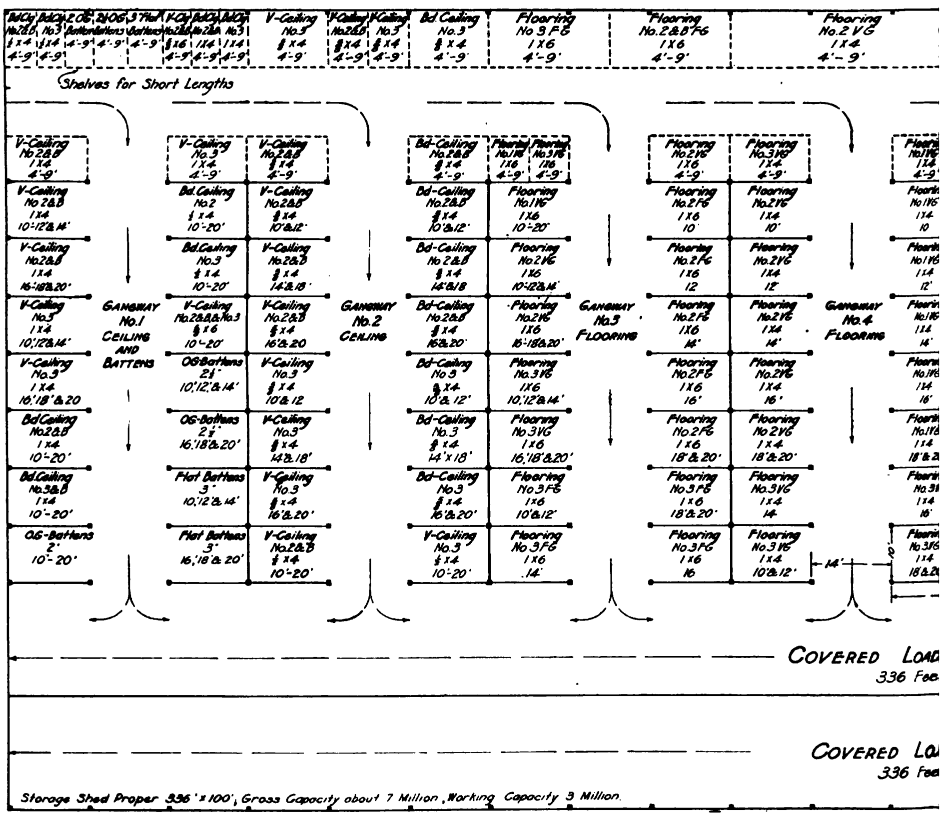


Fig. 54. Plan of lumber

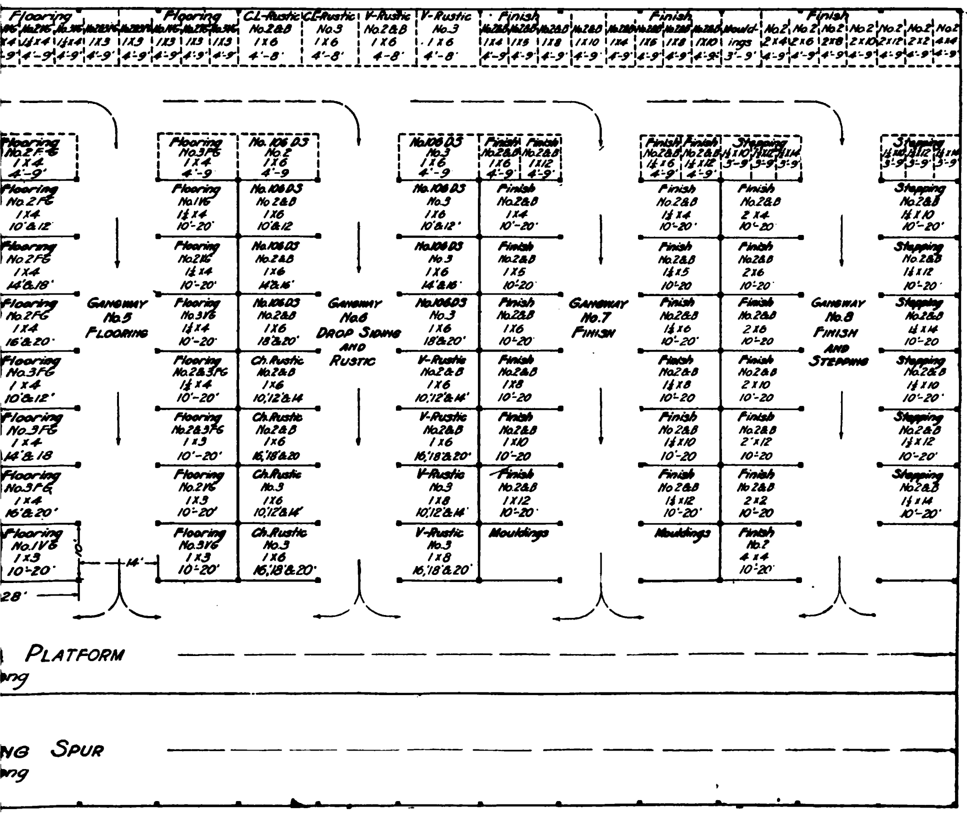
SUMMARIES OF COST OF PRODUCTION

The following detailed estimate was compiled as a reference for making rough calculations of the total cost of producing different classes of lumber under a variety of conditions. The range in cost of a particular step is designed to take care of the various items which influence cost, such as efficiency, wage scale, method of pay, age of plant, and capacity of plant. The figures represent costs per thousand board feet of lumber produced. Those for the various steps in the operation, such as kiln drying and yard piling, are based on the volume of product involved and not upon the total product of the mill.

COST OF PRODUCTION SUMMARIES

(In cents per thousand board feet; Representative 1912-1915)

Item	High, cents	Intermediate, cents	Low, cents
1. Pond:			
a. Labor	9	5	2
b. Supplies	Included in Sawing and Resawing		
c. Repairs (Lab. and Mat.)			
d. Supervision			
2. Sawing and Resawing:			
a. Labor	90	65	50
b. Supplies	18	13	8
c. Repairs (Lab. and Mat.)	75	30	7
d. Supervision	9	6	3



l and allocation of products.

3. Sorting: (Sawmill)			
a. Labor	28	23	21
b. Supplies	Included in		
c. Repairs (Lab. and Mat.)	Sawing and		
d. Supervision	Resawing		
4. Filing: (Sawmill)			
a. Labor	13	9	7
b. Supplies (Saws and Teeth)	10	6	5
5. Oiling: (Sawmill)			
a. Labor	4	3	2
b. Supplies (Oils and Grease)	5	3	2
6. Transportation[1]: (Including Labor, Supplies and Repairs)			
a. Sawmill to Yard*	22	10	3
b. Sawmill to Kiln*	10	5	2
c. Sawmill to P. M.*	14	6	2
d. Sawmill to Cars or Dock*	18	9	3
e. Kilns to Dry Shed*	9	4	2
f. Kilns to P. M.*	10	5	1
g. Kilns to Cars or Dock*	15	7	3
h. Yard to P. M.*	18	8	3
i. Yard to Dry Shed*	18	9	4
j. Yard Cars or Dock*	22	11	4
k. Planing Mill to Shed*	10	5	1
l. Planing Mill to Cars or Dock*	14	6	2
m. Shed to Cars or Dock*	9	4	1
7. Yard:* (by hand)			
a. Piling*	25	22	17
b. Unpiling*	20	15	12
c. Repiling* (based on total air dried)	3	2	1
d. Supplies*	3	2	1
e. Repairs* (Lab. and Mat.)	4	1	0
f. Supervision*	6	4	2
8. Kilns*			
a. Stacking*	25	17	8
b. Unstacking and Sorting*	35	28	15
c. Supplies*	3	2	1
d. Repairs (Lab. and Mat.)*	15	8	2
e. Supervision*	10	5	3
9. Planing Mill:*			
a. Feeding*	20	14	5
b. Trimming*	18	10	5
c. Grading*	4	3	2
d. Sorting and Bundling*	32	20	10
e. Sharpening Knives and Bits*	5	4	1
f. Supplies*	12	10	6
g. Repairs (Lab. and Mat.)*	16	7	3
h. Supervision*	8	6	2
10. Dressed Shed:*			
a. Stacking and unstacking*	25	14	10
b. Supervision*	3	2	.
11. Shipping:			
a. Grading*	20	12	8
b. Loading and Tallying	30	18	11
c. Supplies	6	3	2
d. Supervision	4	3	2
12. Burner:			
a. Labor	5	2	1
b. Repairs (Lab. and Mat.)	6	2	1
13. Power:			
a. Labor (Sawmill)	21	16	12
b. Supplies (Planing Mill)	3	2	1
c. Repairs (Dry Kilns) (Lab. and Mat.) (Transportation)	12	6	3
14. Overhead (Office)			
a. Supervision	35	30	25
b. Fire insurance	23	15	8
c. Liability insurance	12	9	6
d. Taxes	12	6	4
e. Donations and Assessments	10	6	3
f. Advertising	10	2	0
g. Miscellaneous	5	3	2
h. Supplies	6	3	1
15. Selling:			
Salaries and Commissions, etc.	75	60	50
Discounts	25	15	8
16. Depreciation	80	50	28

[1] Prorated from a total on basis of approximate relative distances. It includes horse charges when they are used.

* The items starred are based upon the amount put through the specific operation or sub-classification and not upon the total production.

LOG PRICES

The cost of logs is an important item to operators who have to rely on the log market for all or part of their log supply. The tabulation below gives the average prices paid for the different grades of logs for each year from 1909 to 1918 inclusive. It is apparent that the prices fluctuate considerably. Prior to the war the normal prices were \$6, \$9, and \$12, and only when lumber prices were good did the log prices advance to \$7, \$10, and \$13. The prices maintained during the war were fixed by the government to stabilize the industry.

PRICES OF DOUGLAS FIR LOGS BY REGIONS [1]

1909 to 1918, Inclusive

	GRADE No. 1		GRADE No. 2		GRADE No. 3	
Average for year	Columbia River	Puget Sound	Columbia River	Puget Sound	Columbia River	Puget Sound
1909	\$12.00	\$12.00	\$ 8.50	\$ 9.00	\$ 5.50	\$ 6.00
1910	13.00	13.00	10.00	10.00	7.00	7.00
1911	12.00	12.00	9.00	9.00	6.00	6.00
1912	12.50	12.00	9.50	9.00	6.50	6.00
1913	12.75	13.00	9.50	10.00	6.50	7.00
1914	11.50	11.50	8.50	8.50	5.50	5.50
1915	11.00	11.00	8.00	8.00	5.00	5.00
1916	12.25	12.50	9.25	9.50	6,25	6.50
1917	15.25	14.50	12.25	11.50	9.25	8.50
1918	19.00	19.50	15.75	15.50	11.50	11.50

[1] Compiled from monthly issues of the Timberman.

The prices shown are based on log scale and are considerably higher than the net cost per thousand feet of lumber produced, because of the surplus or overrun of the lumber tally over the log scale.

LOG GRADES AND YIELDS

Owing to the marked difference in the quality or value of the various logs obtained from Douglas fir trees, it has been the practice for several years to classify or grade the logs with respect to their size and the character of lumber they will yield. The following log-grading specifications indicate the general characteristics of the logs comprising each of the three grades in the principal log markets of the region.

COLUMBIA RIVER AND PUGET SOUND LOG SCALING AND GRADING RULES (1918)

No. 1 logs shall be logs which, in the judgment of the representative of the first party, will be suitable for the manufacture of lumber in the grades of No. 2 clear and better, to an amount of not less than 50 per cent of the scaled contents. Such logs shall be of an old growth, fine grain character, reasonably straight grained and for a space of six lineal feet, equi-distant from each end of the log, the grain shall not deviate from a straight line to exceed 1 inch to the lineal foot. No. 1 logs, from 12 feet to 32 feet inclusive, in length, shall be not less than 30 inches in diameter inside the bark at the small end; and from 34 feet to 40 feet inclusive, in length, shall be not less than 28 inches in diameter inside the bark at the small end. Rings, seams or rot are not serious defects in a No. 1 log providing their location and size do not prevent the production of the required percentages in the grades specified. Knots, pitch pockets, etc., are defects which impair the grade only in proportion to their effect on the amount of clear in the log.

No. 2 logs shall be not less than 12 feet in length, having defects which prevent their grading No. 1, but which, in the judgment of the representative of the first party, will be suitable for the manufacture of lumber principally in the grades of No. 1 common and better. No. 2 logs surface clear on two faces, or for one-half the circumference will admit the equivalent of two large knots to each twelve lineal feet.

No. 3 logs shall be not less than 12 feet in length, having defects which prevent their cutting into higher grades and which, in the judgment of the representative of the first party, will be suitable for the manufacture of inferior grades of lumber.

In order to ascertain the amount and character of lumber obtained from the three grades of logs in the Columbia River and Puget Sound log markets, the Forest Service made a series of mill scale or tally studies, the results of which are shown in Table 1. They do not show the final or net amount of lumber actually obtained from each grade of logs, for they represent the volume of rough green lumber, and allowance must be made for losses in volume and changes in grade during the seasoning, machining, and trimming operations. Studies are now in progress to ascertain the extent of these volume losses and changes in grade for the different classes of lumber products.

YIELD OF LUMBER FROM THE THREE GRADES OF DOUGLAS FIR LOGS

No. 1 Logs.

Grade		Columbia River Region Study No. 1 Original Grade	Columbia River Region Study No. 1 Re-Grade	Columbia River Region Study No. 2 Original Grade	Columbia River Region Study No. 2 Re-Grade	Puget Sound Region Study No. 1 Original Grade	Puget Sound Region Study No. 1 Re-Grade	Puget Sound Region Study No. 2 Original Grade	Puget Sound Region Study No. 2 Re-Grade
		Percentages							
No. 1 V.G.	Sound.....	9.2	10.0	6.6	7.4	7.9	5.9	7.2	10.3
	Def........	7.2	6.3	5.1	6.3	12.4	7.8	11.8	13.3
No. 2 V.G.	Sound.....	8.0	8.8	4.0	4.5	4.3	2.6	11.5	12.2
	Def........	3.3	2.8	2.3	2.8	3.1	2.4	9.9	10.8
No. 3 V.G.	Sound.....	3.0	3.9	1.3	1.5	.9	1.0	2.8	2.9
	Def........	1.1	1.0	.8	.9	.6	.9	.6	.9
No. 2 F.G.	Sound.....	44.6	46.6	49.0	55.6	47.4	49.5	37.9	43.6
	Def........	49.7	47.0	39.1	48.6	48.4	51.7	40.3	43.1
No. 3 F.G.	Sound.....	5.0	5.8	4.6	5.2	6.3	4.7	11.1	6.2
	Def........	5.1	4.4	3.6	4.4	3.9	4.7	4.9	2.7
No. 1 Com.	Sound.....	26.0	21.9	28.7	22.5	25.3	30.8	26.0	21.9
	Def........	25.6	28.4	41.6	31.7	28.1	28.0	18.7	17.2
No. 2 Com.	Sound.....	2.4	1.3	2.6	1.2	6.7	3.9	1.4	1.2
	Def,........	3.2	3.5	4.4	3.5	3.1	2.1	5.5	4.2
No. 3 Com.	Sound.....	1.8	1.7	1.5	1.6	1.0	1.6	1.5	1.7
	Def........	3.2	4.8	1.9	1.4	.4	2.3	8.4	7.5
Cull	Sound.....	0.0	0.0	1.7	.5	.2	0.0	0.0	0.0
	Def........	1.6	1.8	1.2	.4	0.0	.1	.5	.4
Per Cent of Total Tally	Sound.....	7.7	14.0	6.2	8.9	6.8	16.3	12.2	11.8
	Def........	10.0	20.4	13.2	13.3	4.9	17.2	34.4	32.6
Net Log Scale	Overrun over	33.0	36.3	24.4	26.5	13.7	19.5	20.4	20.8

No. 2 Logs.

Grade		Columbia River Region Study No. 1 Original Grade	Columbia River Region Study No. 1 Re-Grade	Columbia River Region Study No. 2 Original Grade	Columbia River Region Study No. 2 Re-Grade	Puget Sound Region Study No. 1 Original Grade	Puget Sound Region Study No. 1 Re-Grade	Puget Sound Region Study No. 2 Original Grade	Puget Sound Region Study No. 2 Re-Grade
No. 1 V.G.	Sound.....	2.9	2.5	1.7	1.0	2.6	1.8	5.6	2.8
	Def........	1.7	.9	1.2	.9	4.1	2.0	8.4	.6
No. 2 V.G.	Sound.....	2.4	1.9	.9	.6	1.1	1.2	3.1	3.0
	Def........	.9	.4	.6	.4	2.1	1.0	1.5	1.6
No. 3 V.G.	Sound.....	1.7	1.5	.4	.3	.7	.8	1.6	1.8
	Def........	1.9	1.1	1.3	1.0	.9	2.8	1.1	.7
No. 2 F.G.	Sound.....	32.9	35.9	24.3	15.0	35.9	30.5	38.0	39.4
	Def........	22.4	12.3	15.9	11.2	41.7	28.1	27.5	33.5
No. 3 F.G.	Sound.....	11.4	9.2	3.0	1.9	4.5	4.4	10.8	11.2
	Def........	7.6	4.2	5.4	3.8	5.8	9.9	2.6	8.8
No. 1 Com.	Sound.....	38.3	40.8	63.2	73.3	48.6	54.5	34.5	35.0
	Def........	40.7	39.4	67.6	73.1	34.4	39.9	33.9	38.3
No. 2 Com.	Sound.....	3.2	3.8	4.8	6.3	3.2	3.7	3.7	2.8
	Def........	12.2	15.1	5.3	5.9	4.3	6.9	12.6	7.5
No. 3 Com.	Sound.....	2.8	2.5	1.3	1.1	3.3	3.0	2.6	2.6
	Def........	12.6	14.0	1.9	2.5	6.4	9.0	17.5	8.8
Cull	Sound.....	.4	.5	.4	.5	.1	.1	.1	1.4
	Def........	4.0	4.1	.8	1.2	.3	.4	.9	.4
Per Cent of Total Tally	Sound.....	20.0	24.0	28.5	34.2	40.8	30.7	11.8	13.4
	Def........	40.9	26.6	31.3	39.6	23.1	12.7	10.1	7.3
Overrun over	Net Log Scale	38.0	39.1	19.8	22.1	20.6	20.0	21.3	18.4

No. 3 Logs.

Grade		Columbia River Region Study No. 1 Original Grade	Columbia River Region Study No. 1 Re-Grade	Columbia River Region Study No. 2 Original Grade	Columbia River Region Study No. 2 Re-Grade	Puget Sound Region Study No. 1 Original Grade	Puget Sound Region Study No. 1 Re-Grade	Puget Sound Region Study No. 2 Original Grade	Puget Sound Region Study No. 2 Re-Grade
No. 1 V.G.	Sound.....	.1	.0	.6	0.0	.3	.1	.3	.1
	Def........	1.3	.5	1.6	0.0	1.2	.4	.4	.5
No. 2 V.G.	Sound.....	.5	1.5	.8	0.0	.9	.3	.4	.2
	Def........	.4	.5	.4	0.0	.3	.1	.7	.6
No. 3 V.G.	Sound.....	.3	.1	.6	0.0	.3	.2	.4	.2
	Def........	.1	.2	.1	0.0	.1	.5	.5	.3
No. 2 F.G.	Sound.....	6.5	5.9	4.4	0.0	10.3	6.7	13.5	7.9
	Def........	7.0	3.5	8.4	0.0	17.2	4.5	14.4	11.2
No. 3 F.G.	Sound.....	.6	1.3	0.0	4.4	2.1	2.5	3.6	5.4
	Def........	.1	1.1	1.5	0.0	2.9	1.7	1.2	4.8
No. 1 Com.	Sound.....	64.2	65.1	84.4	92.0	64.4	64.8	64.0	67.3
	Def........	50.2	15.4	75.7	99.0	51.8	54.2	40.4	35.2
No. 2 Com.	Sound.....	20.1	10.5	7.9	6.3	13.8	15.1	10.1	11.0
	Def........	19.0	25.5	6.9	0.0	10.8	16.6	13.7	17.5
No. 3 Com.	Sound.....	7.3	15.2	.8	1.2	7.8	10.1	7.4	7.6
	Def........	18.6	49.2	3.8	0.0	15.7	22.0	27.7	28.5
Cull	Sound.....	.4	.4	.5	.5	.1	.2	.3	.4
	Def........	3.3	4.1	1.6	1.0	0.0	0.0	1.0	1.4
Per Cent of Total Tally	Sound.....	7.0	5.0	10.8	2.4	19.7	18.6	24.6	23.4
	Def........	14.4	10.0	10.0	1.6	4.7	4.5	6.9	11.5
Overrun over	Net Log Scale	40.2	42.2	22.6	47.5	31.0	32.0	23.1	24.2

Note: The Spaulding rule was used in the Columbia River studies and the Scribner Decimal C rule was used in the Puget Sound studies, but there is little difference in the two rules. Attempt should not be made to compare the overrun figures for the two regions. (See text.)

The column headings "Original Grade" and "Regrade" are used to designate the yield from the logs as graded by the scaler before they were cut as against the yield from the logs as graded in the office from an analysis of their actual yield.

The attempt should not be made to compare the overrun figures for the different studies because the net overrun depends largely upon the per cent of defective logs and the scaler's opinion of merchantable lumber. The same scaler was not used in both regions.

FIR LUMBER PRODUCTS

Probably no other species of wood is made into a greater variety of sawmill products than Douglas fir. The detailed data here presented regarding fir lumber products can be considered in the main representative of the majority of rail mills in the region. It should be borne in mind, however, that many plants do not make all of the products mentioned, while others make additional products or greater or less amounts of the sizes, grades, and forms shown. The data are not representative of mills cutting less than 100,000 feet per day, since many such plants are not equipped with dry kilns and make only a few forms.

The various products and forms made can be classified into two main groups, those made from the clear or upper grades of lumber and those made from common or inferior grades. In the former group are flooring, ceiling, drop siding, rustic finish, stepping, car materials, and the like; in the latter are boards, shiplap, dimension timbers, bridge stringers, ties, and similar products. The proportion of each of these two great groups varies directly with the ratio of clear to common grades of lumber in the timber or logs under consideration.

Although there is a direct relation between these two main groups of products and the quantity of clear and common material, the proportion of the upper or lower grades suitable for a given form of product is not uniform, since the character of the grain of the wood, the type of knots, the presence of decay, and other physical characteristics have an important bearing on whether the wood is suitable for this or that product. For example: The better grades of flooring, stepping, decking, etc., must be made from vertical grain material, and stringers, joists, and similar products should be free from decay, and from large or loose knots which may impair their strength. For this reason the proportion of the different forms is governed to a certain extent by the character of both the clear and the common lumber obtained from the logs. This accounts for the range in the percentage figures given for the proportion of the lumber suitable for each of the products.

The grading, size, specifications, and patterns are taken from the rules issued by the West Coast Lumbermen's Association, January 1, 1917.

FLOORING

The clear grades of lumber suitable for floorings form from 20 to 35 per cent of the output from average logs, and about 35 per cent of all the clear is ordinarily put into this product. From the standpoint of both quantity and price obtained, it is the principal product made from the upper grades of fir.

Flooring is manufactured and sold under two classifications, vertical grain and flat grain. Vertical grain flooring is sawed so that the annual rings lie at right angles or not less than a 45° angle to the top and bottom faces of the piece. In flat grain flooring the rings lie parallel, or nearly so, to these faces. Under average conditions 65 per cent of the flooring is sawed vertical grain and 35 per cent flat grain, the amount depending upon orders, logs, and sawing practice.

Vertical grain flooring is preferred and commands a higher price than flat grain, as it is more resistant to abrasion. It is manufactured into the three following grades:

"No. 1 Clear—Vertical Grain, 3, 4, and 6 inch. Shall be well milled on face, must have perfect edges and be practically free from all defects. Bright sap showing not more than one-third of face half the length of piece will be admitted. Angle of grain not less than 45 degrees.

"No. 2 Clear—Vertical Grain, 3, 4, and 6 inch. Shall be well manufactured. Angle of grain not less than 45 degrees. Will admit of slight roughness in dressing, from one to three small, close pitch pockets or equivalent defects.

"No. 3 Clear—Vertical Grain, 3, 4, and 6 inch. Angle of grain not less than 45 degrees. Will admit of roughness in dressing; slightly discolored sap, two small knots or four small pitch pockets, any two of which may be open. It is generally understood that this grade will admit such defects or combination of defects as will not impair the utility for cheap floors. A piece 12 feet or longer otherwise as good as No. 2 may have a defect that can be cut out and the piece laid with a loss of not more than 2½ inches in its length, providing the defect is 4 feet or more from the end of the piece."

Flat grain flooring is manufactured into the following three grades:

"No. 2 Clear and Better—Flat Grain, 3, 4, and 6 inch. Shall be well manufactured; will admit of slight roughness in dressing. Either of the following defects also permitted with the above: Three close pitch pockets, not to exceed two inches each in length; one sound and tight smooth pin knot, or the equivalent of combined defects.

"No. 3 Clear—Flat Grain, 3, 4, and 6 inch. Will admit of roughness in dressing, slightly discolored sap; two small knots, or four small pitch pockets, any two of which may be open; or the equivalent of combined defects. A piece 12 feet or longer, otherwise as good as No. 2 and Better, may have a defect that can be cut out and the piece laid with a waste of not more than 2½ inches in its length, providing the defect is 4 feet or more from the end if the piece. It is generally understood that this grade will admit such other defects or combination of defects as will not impair its utility for cheap floors and sheathing. Hemlock permitted, but not more than 15 per cent.

"No. 4 Clear—Flat Grain, i. e., 13/16-inch thick or ¾-inch thick, and, or Vertical Grain, i. e., 13/16-inch thick, 3, 4 and 6 inch, will admit of numerous small or several medium or large pitch pockets; excessive heart and, or, sap stain; a limited amount of rot; small knots, imperfect manufacture; a few scattered worm holes or a small knot hole if located 3 feet or more from the end of the piece. A very serious combination of above defects not permissible in any one piece. Hemlock, in any quantity, permitted."

Flooring is manufactured into the following sizes:

"¾ x 3, ¾ x 4, ¾ x 6-inch shall be finished ⅝ x 2¼, 3¼ and 5⅛-inch face; 1 x 3, 1 x 4, 1 x 6, V. G., and 1 x 4 F. G., shall be finished 13/16 x 2¼, 3¼ and 5⅛ face.

1 x 6 F. G., shall be finished ¾ x 5⅛ face.

1¼ x 3-inch, 4-inch and 6-inch shall be finished 1 1/16 x 2¼-inch, 3¼-inch and 5⅛-inch face.

1½ x 3-inch, 4-inch and 6-inch shall be finished to 1 5/16 x 2¼-inch, 3¼-inch and 5⅛-inch face.

Flooring is tied into bundles to facilitate handling for shipment, 1 x 3-inch, 1¼ x 3-inch and 1 x 4-inch flooring having 6 pieces to the bundle, and 6-inch flooring 4 pieces to the bundle. It is usually sold in lengths which are multiples of one foot from 4 to 9 inclusive and multiples of 2 feet in lengths above 10 feet.

The percentages of each size and grade ordinarily manufactured are shown in the following tables:

APPROXIMATE PERCENTAGE OF EACH LENGTH OF FLOORING PRODUCED FROM TYPICAL SIZES AND GRADES[1]

Size	Grade	4	5	6	7	8	9	10	12	14	16	18	All
		Length in Feet / Percentage											
1 x 3	1 V.G.	0.7	0.4	0.7	0.2	0.1	0.3	17.8	23.4	10.0	34.9	11.5	100%
1 x 4	1 V.G.	2.8	1.6	4.6	3.0	8.0	3.7	13.1	20.3	22.2	20.2	0.5	100%
1¼ x 4	1 V.G.	.	.	2.1	2.0	3.6	1.8	8.5	26.6	26.2	27.3	1.9	100%
1 x 4	2 V.G.	1.2	1.3	3.7	2.3	6.4	2.0	10.5	19.6	22.9	26.5	3.6	100%
1¼ x 4	2 V.G.	0.1	0.1	1.4	1.6	5.6	0.9	6.9	17.8	24.4	40.6	0.6	100%
1 x 4	3 V.G.	3.5	1.5	3.4	2.3	7.1	4.9	11.8	20.3	21.7	22.6	0.9	100%
1¼ x 4	3 V.G.	0.6	0.7	3.7	2.0	4.0	1.8	9.0	20.0	21.8	32.8	3.6	100%
1 x 4	2 & Btr. F.G. ..	1.5	1.2	3.4	1.5	6.2	1.8	10.7	21.8	27.0	24.3	0.6	100%
1 x 6	2 & Btr. F.G. ..	1.6	0.2	4.2	.	7.3	.	14.8	22.0	27.2	22.7	0.0	100%
1 x 4	3 Clr. F.G.	5.0	2.6	3.6	0.2	5.0	1.2	11.3	18.7	28.0	24.3	0.1	100%
1 x 6	3 Clr. F.G.	1.9	.	3.5	.	5.5	.	11.5	26.1	26.0	23.6	1.9	100%

[1] Data on No. 4 F. G. flooring were not available.

APPROXIMATE PERCENTAGE OF FLOORING MANUFACTURED INTO THE VARIOUS SIZES AND GRADES; ALSO PERCENTAGE OF EACH SIZE BY GRADES

Sizes Inches	Per cent Index	1 VG	2 VG	3 VG	FG	3 FG	Totals
		GRADES / Percentages					
1 x 3	All Flg. ...	0.1	0.2	0.1	..	..	0.4
	1 x 3 in.	25.0	50.0	25.0	..	..	100.0
1 x 4	All Flg. ...	14.9	34.2	9.5	9.4	2.3	70.3
	1 x 4 in.	20.9	49.4	13.4	13.0	3.3	100.0
1 x 6	All Flg. ...	..	..	..	14.6	9.5	24.1
	1 x 6 in.	..	..	..	60.8	39.2	100.0
1¼ x 4	All Flg. ...	1.1	2.7	1.4	..	..	5.2
	1¼ x 4 in.	22.2	51.6	26.2	..	..	100.0

Note: 1 x 6 inch V.G., 1¼ x 3 inch, and 6 inch V.G. and F.G. Flooring are manufactured in too small amounts to show in this table. Data were not available on No. 4 F.G. Flooring.

DROP SIDING AND RUSTIC

Drop siding and rustic are second only to flooring in importance as fir products from clear lumber, practically all of which is suitable for these forms. Approximately 30 per cent of the clear grades are made into them.

They are made in three grades as follows (1917):

No. 2 Clear and Better—4, 6 and 8-inch. Defects based on piece 6 inches wide, 12 feet long. Shall be well manufactured. Slight roughness in dressing admissible; will allow three sound and tight pin knots or four tight pitch pockets or their equivalent of combined defects. Hemlock permitted but not more than 15 per cent.

A piece 14 feet or longer may have one defect located 4 feet or more from the end, that can be cut out by wasting not more than 1½ inches of the length, provided balance of piece be practically free from other defects.

No. 3 Clear—4, 6 and 8-inch. Will admit of roughness in dressing; slightly discolored sap; three sound and tight knots not larger than 1-inch in diameter; or five small pitch pockets, any three of which may be open; a small number of pin worm holes; or the equivalent of combined defects. A piece that is otherwise as good as No. 2 may have a defect that can be cut out by wasting not more than 2½ inches in the length of the piece, providing the defect is 4 feet or more from the end. Hemlock, in any quantity, permitted.

No. 4 Clear—4, 6 and 8-inch. Will admit of numerous small or several medium or large pitch pockets; excessive heart and, or, sap stain; small knots; a couple of small knot holes; imperfect manufacture; pin worm holes or a few well scattered grub worm holes. A very serious combination of above defects not permissible in any one piece. Hemlock, in any quantity, permitted.

Sizes of Fir Drop Siding

⅝ x 6-inch, No. 105, finished 9/16 x 4⅞-inch face, ½-inch rabbet; ⅝ x 6-inch, No. 106, finished 9/16 x 5⅛-inch face, 1 x 6-inch, No. 105 finished ¾ x 4⅞-inch face, ½-inch rabbet; 1 x 4-inch, 6-inch, and 8-inch, No. 106, finished ¾ x 3¼-inch, 5⅛-inch, and 7-inch, ¼-inch tongue. Standard lengths are multiples of two feet.

Size of Fir Rustic

⅝ x 6-inch and 8-inch Channel, finished 9/16 x 4⅞-inch, and 9/16 x 6¾-inch face, ½-inch rabbet; 1 x 6 and 8-inch channel, finished ¾ x 4⅞-inch, and 6¾-inch face, ½-inch rabbet; ⅝ x 6 and 8-inch V and center-V, finished 9/16 x 4⅞-inch and 6¾-inch face, ½-inch rabbet; 1 x 6 and 8-inch V and center-V, finished ¾ x 4⅞-inch, and 6¾-inch face, ½-inch rabbet. Standard lengths are multiples of two feet.

1 x 6 inch forms 99.9 per cent of all drop siding and rustic, of which 75.4 per cent is No. 2 Clr. and Btr., 20.0 per cent is No. 3 Clr., and 4.6 per cent is No. 4 Clr.

Drop siding and rustic are made in even lengths and are priced in groups of 4 feet, 6 feet, 8 feet, and 10 feet and longer.

PER CENT OF EACH LENGTH, DROP SIDING AND RUSTIC

		Length in Feet									
		4	6	8	10	12	14	16	18	20	All
Size	Grade	Percentages									
1 x 6	2 & Btr. ...	2.4	5.0	8.5	10.1	21.7	28.3	21.5	2.1	0.4	100%
1 x 6	3 Clr.	2.2	4.9	9.1	12.1	21.0	24.8	22.4	3.0	0.5	100%
1 x 8	3 Clr.	.	.	0.8	11.8	33.1	27.1	24.1	1.8	1.3	100%
1 x 4	4 Clr.	2.0	7.1	10.5	16.6	21.1	14.0	21.0	7.7	.	100%
1 x 6	4 Clr.	.	0.9	1.1	1.5	16.2	14.7	64.1	1.5	.	100%

CEILING AND PARTITION

Ceiling and partition are manufactured from the clear or upper grades of lumber, of which about 10 per cent is ordinarily put into them. A larger proportion of the clear lumber is more suitable for ceiling and partition than for flooring. From 25 to 40 per cent of the cut is used for this purpose.

These products are manufactured into three grades as follows (1917):

"No. 2 Clear and Better—Flat Grain and, or, Vertical Grain, 3, 4 and 6 inch. Shall be well manufactured; will admit of slight roughness in dressing. Either of the following defects also permitted with the above: Three close pitch pockets, each not to exceed two inches in length; one sound and tight smooth pin knot, or the equivalent of combined defects. Hemlock permitted, but not more than 15 per cent.

"No. 3 Clear—Flat Grain and, or, Vertical Grain, 3, 4 and 6 inch. Will admit of roughness in dressing; two small knots; slightly discolored sap; or four small pitch pockets, any two of which may be open, or the equivalent of combined defects. A piece otherwise as good as No. 2 may have a defect that can be cut out and the piece laid with a waste of not more than 2½ inches in its length, providing the defect is 4 feet or more from the end of the piece. Hemlock, in any quantity, permitted.

"No. 4 Clear—Flat Grain and, or, Vertical Grain, 3, 4 and 6 inch. Will admit of numerous small or several medium or large pitch pockets; excessive heart and, or, sap stain; small knots; imperfect manufacture and, or, a few well scattered worm holes; and one small knot hole if located 3 feet or more from the end of the piece. A very serious combination of above defects not permitted in any one piece. Hemlock, in any quantity, permitted.

"In all grades of Ceiling wane on the reverse side, not exceeding one-third the width and one-sixth the length of any piece, is admissible, providing the wane does not extend into the tongue."

Size of Fir Ceiling

"Ceiling shall be worked to the following:

⅜ x 3-inch, 4-inch and 6-inch finished 5/16 x 2¼-inch, 3¼-inch and 5⅛-inch.

½ x 3-inch, 4-inch and 6-inch finished 7/16 x 2¼-inch, 3¼-inch and 5⅛-inch face.

⅝ x 3-inch, 4-inch and 6-inch finished 9/16 x 2¼-inch, 3¼-inch and 5⅛-inch.

1 x 3-inch, 4-inch and 6-inch finished 11/16 x 2¼-inch, 3¼-inch and 5⅛-inch.

Standard lengths are multiples of one foot.

Sizes of Fir Partition

1 x 4 and 6 inch finished 11/16 x 3¼-inch and 5⅛-inch face. Standard lengths are multiples of one foot. Partition 4 or 6-inch, shall be graded from the poorest side.

Ceiling and partition are manufactured in lengths which are multiples of one foot from 4 to 9 feet inclusive, and multiples of two feet above 10 feet. A large number of mills, however, cut only even length pieces. Ceiling and partition are bundled 6 pieces to a bundle.

APPROXIMATE PERCENTAGE OF CEILING AND PARTITION MANUFACTURED INTO THE VARIOUS SIZES AND GRADES; ALSO PER CENT OF EACH SIZE BY GRADES

Size, Inches	Per cent, Index	Grades No. 2 Clr. & Btr., Per cent	No. 3 Clr., Per cent	Total, Per cent
⅜ x 4	All Clg. & P.	0.2	..	0.2
	⅜ x 4	100.0	..	100.0
⅝ x 4	All Clg. & P.	79.8	12.8	92.6
	⅝ x 4	83.8	16.2	100.0
1 x 4	All Clg. & P.	4.9	..	4.9
	1 x 4	100.0	..	100.0
1 x 6	All Clg. & P.	2.3	..	2.3
	1 x 6	100.0	..	100.0
Totals				
	All Clg. & P.	87.2	12.8	100.0

Note: Other sizes of ceiling and partition are usually manufactured in too small amounts to be included in this table. Data are not available on No. 4 F.G. ceiling and partition.

PERCENTAGE OF EACH LENGTH

Size, Inches	Grade	4	6	8	10	12	14	16	18	20	All
		Length of Feet / Percentages									
⅜ x 4	2 & Btr. ..	0.9	2.6	6.4	11.0	17.6	21.4	26.1	14.0	.	100%
⅝ x 4	2 & Btr. ..	5.1	9.9	13.3	14.4	18.7	19.8	17.1	1.7	.	100%
1 x 4	2 & Btr. ..	0.5	2.2	7.5	17.4	27.5	19.0	21.4	4.3	0.2	100%
1 x 6	2 & Btr. ..	0.7	2.2	8.8	28.7	17.5	12.8	29.3	.	.	100%
⅝ x 4	3 Clr.	2.5	6.9	11.1	18.7	23.0	17.7	16.7	3.4	.	100%

SILO STAVES

From 25 to 45 per cent of the lumber from average logs will make silo staves, which are manufactured from clear and select common stock. Although the amount is not uniform in different mills, about 10 per cent of the clear lumber is ordinarily used for this product.

Silo stock is made into two grades, as follows (1917):

No. 2 Clear and Better—Must be square edged and water-tight the full length of the piece. Will admit any one of the following: Three sound and tight small knots; or three small dark colored knots, if not extending through the piece; one medium pitch pocket or its equivalent of smaller pitch pockets, providing pitch pockets do not extend through the thickness of the piece; small, fine season checks; or the equivalent of combined defects. In absence of either one of the above a piece may have one larger season check if not over 1/16 inch in open width, not over 12 inches long and extending not more than half way through the piece. Bright sap no defect. Warped or crooked pieces not admissible. Based on piece 12 feet long.

Selected Common—Must be square-edged and water-tight the full length of the piece. Will admit of any number of sound and tight standard knots, or pitch pockets, not over 6 inches long that do not extend through the thickness of the piece. Bright sap no defect. A slight amount of stained sap admissible.

The staves are made from pieces 2 x 6 inches and are designed to be used for silos having a diameter of 16 feet.

This product is almost entirely manufactured from No. 2 Clear and Better lumber, the per cent of Select Common used being so small as to be practically negligible.

All lengths from 2 feet to 40 feet are manufactured in multiples of two feet, and prices vary with the lengths. The proportion of the various lengths ordinarily obtained is shown below.

PERCENTAGE OF EACH LENGTH

Feet	Per cent	Feet	Per cent	Feet	Per cent
2	0.2	14	2.7	26	3.3
4	.3	16	3.1	28	7.3
6	.9	18	8.3	30	14.2
8	1.6	20	9.0	32	18.7
10	3.7	22	6.7	34	2.3
12	5.3	24	12.4	..	..

FINISH

Douglas fir finish is manufactured entirely from clear lumber, from 5 per cent to 20 per cent of the mill run supply being suitable for this purpose. About 4 per cent of the clear lumber is normally used.

Finish is manufactured in three grades, as given below (1917), and in a wide variety of sizes. Though usually cut flat grain, it is also manufactured into vertical grain stock.

Selected Flat Grain—1, 1¼, 1½ and 2 inches thick, 4 to 12 inches wide. Shall be free from sap and all defects, on face and edges, and selected for beauty and character of grain.

No. 2 Clear and Better—Flat Grain and, or Vertical Grain, based on 1 x 8″-12′. Rule to apply proportionately on narrower or wider and thicker stock. Will admit of slight roughness in dressing. Will allow 5 per cent straight splits not longer than the width of the piece; or a small amount of stain on the reverse side of the piece. In addition to one of the above, three small tight pitch pockets, each not to exceed two inches in length will be allowed, or the equivalent of combined defects.

No. 3 Clear—Flat Grain, and, or, Vertical Grain, 1, 1¼, 1½ and 2 inches thick, 4 to 12 inches wide, based on 1 x 8″ - 12′. Rules to apply proportionately on narrower and wider and thicker stock. Will admit 5 per cent straight splits not longer than the width of the piece; medium torn grain, heavy torn grain in two or three places; season checks that do not go through; stain covering one-fourth of the face of the piece. With any one of the above, one of the following or their equivalent of combined defects will be allowed: Four small pitch pockets or their equivalent of larger pockets; one standard pitch streak; four small and tight sound knots; two 1-inch knots or their equivalent of pin knots, or other defects. A piece 14 feet or longer may have a defect located six or more feet from the end of the piece that can be cut out by wasting not more than 1½ inches in length, provided balance of piece be practically free from defects.

Sizes of Fir Finish

Thickness S1S or S2S, 1-inch to ¾-inch; 1¼-inch to 1$\frac{1}{16}$-inch; 1½-inch to 1$\frac{5}{16}$-inch; 2-inch to 1¾-inch. Widths if dressed one or two edges; 4-inch, 5-inch and 6-inch, finished to 3½ inches, 4½ inches and 5½ inches; 8-inch, 10-inch and 12-inch, finished to 7¼ inch, 9¼ inch and 11¼ inch; 14-inch and 16-inch, finished to 13 inches and 15 inches. Standard lengths are multiples of one foot.

Finish is sold surfaced on one or both faces, one or both edges, or any combination of faces and edges. Most commonly it is surfaced on both faces and both edges. It is also sold rough. When rough, it is sold both green and kiln dried, but when surfaced, is customarily sold dried.

APPROXIMATE PERCENTAGE OF FINISH MAUFACTURED INTO VARIOUS SIZES AND GRADES

Size, Inches	Grade: No. 2 Clr. & Btr., Per cent	Grade: No. 3 Clr., Per cent	Size, Inches	Grade: No. 2 Clr. & Btr., Per cent	Grade: No. 3 Clr., Per cent
1 x 4	9.4	2.5	1¼ x 12	1.5	.4
1 x 5	4.3	1.1	2 x 2	1.5	.4
1 x 6	11.9	3.2	2 x 4	2.9	.7
1 x 8	13.5	3.6	2 x 6	4.8	1.2
1 x 10	8.7	2.3	2 x 8	3.2	.8
1 x 12	10.0	2.6	2 x 10	1.3	.3
1 x 14	.1	.	2 x 12	1.9	.5
1¼ x 4	.4	.1	2 x 14	.1	.
1¼ x 5	.1	.	3 x 4	.1	.
1¼ x 6	.8	.2	3 x 8	.1	.
1¼ x 8	.7	.2	4 x 4	1.9	.5
1¼ x 10	1.0	.2	Totals	80.2	19.8

Note: Methods of manufacturing finish vary to such an extent in the per cent of No. 2 Clr. and Btr. and No. 3 Clr. made that reliable figures on the proportion of each size by grades are not available: the above are estimates.

APPROXIMATE AMOUNT WHICH CLEAR LUMBER WILL PRODUCE IN FINISH BY LENGTHS

Size Inches	Grade	Length in Feet: 4	6	8	10	12	14	16	18	20	22	All
		Percentages										
1 x 3	2 Clr. & Btr...	1.1	0.6	13.8	21.7	32.6	19.6	10.6	..	..	..	100.0
1 x 4	2 Clr. & Btr...	0.2	0.5	3.9	5.6	13.2	41.5	35.1	..	..	..	100.0
1 x 5	2 Clr. & Btr...	0.1	0.2	1.3	8.5	29.5	26.4	32.3	1.7	..	..	100.0
1 x 6	2 Clr. & Brt...	1.0	0.1	0.5	4.1	28.2	37.6	27.6	0.9	..	..	100.0
1 x 8	2 Clr. & Btr...	2.4	5.0	13.2	12.3	24.2	21.0	18.2	3.7	..	..	100.0
1 x10	2 Clr. & Btr...	..	2.1	2.4	15.3	21.5	29.1	22.3	5.6	1.7	..	100.0
1 x12	2 Clr. & Btr...	..	0.5	2.2	11.3	23.8	25.0	34.0	3.2	..	..	100.0
1 x14	2 Clr. & Btr...	..	..	..	..	38.9	49.0	12.1	..	..	..	100.0
1¼x 4	2 Clr. & Btr...	4.5	14.1	43.5	5.9	9.7	..	20.9	1.4	..	..	100.0
1¼x 6	2 Clr. & Btr...	..	1.6	4.2	9.2	39.7	14.6	30.7	..	..	..	100.0
1¼x 8	2 Clr. & Btr...	..	..	..	4.1	21.5	36.2	..	..	..	..	100.0
1¼x10	2 Clr. & Btr...	..	0.5	3.0	12.8	20.8	21.7	33.5	7.7	..	..	100.0
1¼x14	2 Clr. & Btr...	..	..	..	..	4.5	21.7	73,8	..	..	..	100.0
2 x 2	2 Clr. & Btr...	2.0	5.2	4.6	7.5	7.5	8.5	21.0	12.5	31.2	..	100.0
2 x 3	2 Clr. & Btr...	..	..	..	2.8	13.5	15.7	42.7	25.3	..	..	100.0
2 x 4	2 Clr. & Btr...	..	..	5.4	9.6	21.3	24.1	38.8	0.8	..	..	100.0
2 x 6	2 Clr. & Btr...	..	..	..	4.6	50.5	16.3	20.1	4.9	3.1	0.5	100.0
2 x 8	2 Clr. & Btr...	..	..	..	..	16.1	45.5	38.4	..	..	..	100.0
1 x 3	No. 3 Clr.....	..	8.4	7.5	16.3	28.8	17.4	17.4	4.2	..	..	100.0
1 x 4	No. 3 Clr.....	..	2.4	6.4	4.4	16.4	30.5	39.9	..	..	..	100.0
1 x 5	No. 3 Clr.....	..	5.0	5.5	8.4	22.5	27.8	25.1	5.7	..	..	100.0
1 x 6	No. 3 Clr.....	..	6.7	5.6	29.4	40.5	..	17.8	..	..	..	100.0
1 x 8	No. 3 Clr.....	..	3.8	7.0	22.3	26.3	23.7	13.6	3.0	0.3	..	100.0
1 x10	No. 3 Clr.....	..	6.4	14.2	24.5	19.4	18.3	12.5	4.2	0.5	..	100.0
1 x12	No. 3 Clr.....	0.2	1.4	5.5	11.9	32.5	25.2	17.1	6.2	..	..	100.0
1¼x 6	No. 3 Clr.....	..	1.4	1.8	6.2	33.4	32.5	24.7	..	..	..	100.0
1¼x10	No. 3 Clr.....	..	..	17.4	19.4	8.7	34.1	9.6	10.8	..	..	100.0
1¼x12	No. 3 Clr.....	..	..	5.2	6.2	23.3	65.3	..	..	..	..	100.0
2 x 4	No. 3 Clr.....	0.1	..	0.2	4.0	13.1	22.3	60.3	..	..	..	100.0
2 x 6	No. 3 Clr.....	..	..	0.9	0.1	10.8	33.3	53.0	0.9	1.0	..	100.0
2 x 8	No. 3 Clr.....	..	0.2	0.7	2.3	21.9	26.0	47.2	1.7	..	..	100.0
2 x10	No. 3 Clr.....	..	..	..	3.0	36.6	33.9	26.5	..	..	..	100.0
2 x12	No. 3 Clr.....	..	..	..	2.0	40.1	23.3	34.6	..	..	..	100.0

STEPPING

Fir stepping is manufactured from clear lumber, of which from 5 per cent to 10 per cent of an average mill run is available for this product. Normally only about 0.5 per cent of the clear is used for stepping, owing to the limited demand for it. It is made into two grades (1917), as given below, and is sold both flat grain and vertical grain. It is surfaced on both faces and one edge is nosed.

No. 2 Clear and Better—Vertical Grain. 8 to 14-inch. Defects based on piece 10 inches wide and 12 feet long. Shall be well manufactured. Will allow slight roughness in dressing or five small pitch pockets, each not exceeding 2 inches in length of their equivalent of larger pockets. With one of the foregoing defects, may have one to three knots that do not show more than 1½ inches on riser edge of the face side or flat grain one-fourth of the face on the riser edge.

No. 3 Clear—Vertical Grain. Will admit of medium torn grain in two or three places; season checks that do not go through; stain covering one-fourth of the face of the piece. With any one of the above, one of the following or their equivalent of combined defects will be allowed; eight small pitch pockets or their equivalent of larger pockets; wane ½ inch deep on back edge, one standard pitch streak, four small knots; two 1-inch knots.

Sizes 1¼ inch S1S or S2S, finished to 1 1/16, 1½ inch to 1 5/16, 2 inch to 1¾ inch in thickness. Widths if dressed one or two edges, 8 inch, 10 inch and 12 inch, finish to 7¼ inches, 9¼ inches and 11¼ inches; 14-inch to 13 inches. Standard lengths are multiples of one foot.

From an average run of logs, the following proportions of each size and grade are ordinarily produced.

APPROXIMATE PERCENTAGE OF STEPPING MANUFACTURED INTO THE VARIOUS SIZES AND GRADES; ALSO PERCENTAGE OF EACH SIZE BY GRADES

Sizes, Inches	Per cent, Index	1 VG	2 VG	3 VG	2 & Btr. FG	3 FG	Totals,
		Grades Percentages					
1 x 6	All Stp.	.	0.6	.	.	.	0.6
	1 x 6 in. ..	.	100.0	.	.	.	100.0
1¼ x 10	All Stp.	0.4	10.3	.	9.7	1.1	21.5
	1¼ x 10 in. ..	1.8	47.9	.	45.1	5.2	100.0
1¼ x 12	All Stp.	.	24.8	1.3	31.2	4.7	62.0
	1¼ x 12 in. ..	.	40.1	2.2	50.1	7.6	100.0
1¼ x 14	All Stp.	.	.	0.5	.	.	0.5
	1¼ x 14 in. ..	.	.	100.0	.	.	100.0
1½ x 14	All Stp.	.	4.9	.	.	.	4.9
	1½ x 14 in. ..	.	100.0	.	.	.	100.0
2 x 12	All Stp.	.	.	.	10.5	.	10.5
	2 x 12 in. ..	.	.	.	100.0	.	100.0
Totals	All Stp.	0.4	40.6	1.8	51.4	5.8	100.0

PERCENTAGE OF EACH LENGTH

Size, Inches	Grade	6	8	10	12	14	16	18	All
		Feet Percentages							
1¼ x 10	2 & Btr. V.G.	1.1	1.6	10.9	15.3	31.4	39.7	.	100
1¼ x 12	2 & Btr. V.G.	0.2	4.6	11.3	34.0	23.8	25.3	0.8	100
1½ x 14	2 & Btr. V.G.	.	.	.	28.6	33.3	38.1	.	100
1¼ x 12	3 V.G.	.	1.5	15.0	20.0	21.6	39.9	2.0	100
1¼ x 14	3 V.G.	3.0	2.0	10.0	25.0	22.0	35.0	3.0	100
1¼ x 10	2 & Btr. F.G.	0.6	1.8	10.1	25.6	22.2	34.7	5.0	100
1¼ x 12	2 & Btr. F.G.	.	.	7.1	28.5	27.7	36.7	.	100
1¼ x 10	3 F.G.	.	1.3	10.4	27.1	36.3	24.9	.	100
1¼ x 12	3 F.G.	0.6	2.4	7.9	14.8	20.7	51.8	1.8	100

FIR BATTENS

Battens and mouldings usually form about 2 per cent of the clear lumber products. They are made under the specification of the No. 2 Clr. and Btr. grade. Two patterns are cut, flat and O.G. Flat battens are ⅝ x 2½ inches and O.G. has the pattern detail as shown, in widths of 2, 2½, and 3 inches.

TANK STOCK

Tank stock is all graded No. 2 Clr. and Btr. in accordance with the following specifications (1917):

Flat Grain and, or, Vertical Grain. Unseasoned, must be well manufactured, and water-tight the full length, unless it is for cutting stock. Will allow occasional slight variation in sawing; small knots or pitch pockets that do not extend through the piece. If not for cutting stock, edges must be practically clear and contain no defects that will prevent a water-tight joint when worked. Two-inch stock to contain practically no sap, 3 inch and thicker stock when 6 inches and wider, to allow bright sap one-third of face side, not to extend over ¾ of an inch through the piece.

If surfaced, finished size to be ¼-inch less than rough size in thickness and ½-inch less than rough size in width.

MOULDED CASING AND BASE

Moulded casing and base are graded by the rules governing No. 2 Clr. and Btr. Finish.

FIR TURNING SQUARES

Fir squares are sold rough for turning and S4S for use as columns. The following rule governs the grading (1917):

No. 2 Clear and Better—May contain such defects as will remove in dressing or turning; will also admit a few small, sound and tight knots or small pitch pockets or any minor defects that will cover well with paint after working.

FIR WINDMILL STOCK

Windmill stock is used in building windmill towers. It is manufactured to meet the grade of Select Common.

WELL TUBING

Well tubing is manufactured from No. 2 Clr. and Btr. stock into a dressed and matched pattern.

WELL CURBING

Well curbing is graded as No. 1 Common and Select Common, and is cut to a standard pattern. Stock used for its manufacture is 1 x 6 inches and 2 x 6 inches.

WAGON BOX BOTTOMS

Wagon box bottoms are made in sets which are 38 and 42 inches wide and either $\frac{13}{16}$ or $1\frac{1}{16}$ inch thick. The standard length is 11 feet. Both vertical and flat grain stock is used. The pieces which form the sets are dressed and matched. They are graded to the same specifications as No. 2 Clr. and Btr. Flat Grain Flooring. From 95 to 100 per cent of all bottoms made are vertical grain. The most common sizes are $\frac{13}{16}$ x 38 inches and $1\frac{1}{16}$ x 38 inches.

FIR PICKETS

Pickets are cut from No. 2 Clr. and Better material under the following specifications (1917):

Square pickets will admit minor defects, such as slight roughness in dressing, an occasional pin knot or a couple of small pitch pockets.

Flat Pickets will admit slight roughness in dressing; one or two small close pitch pockets or one to two small, sound, tight knots.

PIPE STAVE STOCK

Pipe staves are manufactured from No. 2 Clr. & Btr. lumber under the following standard specification (1917):

Flat Grain and, or, Vertical Grain.—Will allow sound and tight knots or small pitch pockets that do not go through the piece, bright sap on the inside of the stave not extending more than half way through the piece. Edges must be practically clear or contain no defects that will prevent a water-tight joint when worked.

FIR FACTORY LUMBER

Factory lumber is graded under the following rules and specifications (1917):

Factory Plank—Grades as described under this head are valued for cutting qualities only, and should not be confounded, either in quality or value, with grades outlined for yard purposes. Factory plank of all kinds shall be graded for the percentage of Door Cuttings that can be obtained.

Two grades of Door Cuttings only shall be recognized, and are to be known as No. 1 and No. 2 Cuttings. The only defect admissible in No. 1 and No. 2 Door Cuttings is bright sap. The grade of No. 2 Door Cuttings will

admit of one defect only in any one piece. This may be a small knot of sound character not to exceed ⅝ inch in diameter, or the defect may be slightly stained sap, which does not extend over more than half the surface of the piece on one side, or one pitch pocket not more than 2 inches long and not extending through the piece.

Unless otherwise agreed, Fir Factory stock, excepting one-inch stock, shall contain not less than 65 per cent of vertical grain stock.

Factory Select and Better—The grade of Factory Select and Better shall contain 70 per cent and more of No. 1 Door Cuttings in the sizes specified as admissible in No. 1 Shop Common.

No. 1 Shop Common—The sizes and grades of cuttings admissible in the grade of No. 1 Shop common are: (1) No. 1 Stiles in width 5 or 6 inches and in length from 6 ft. 8 in. to 7 ft. 6 in. (2) No. 1 Rails, 9 or 10 inches wide and from 2 ft. 4 in., to 3 ft. in length. (3) No. 1 Muntins, 5 inches wide and from 3 ft. 6 in. to 4 ft. in length. (4) Any number of pieces of either Stiles or Rails mentioned above are admissible in the grade of No. 1 Shop Common, but only two Muntins of the sizes mentioned above shall be considered and one No. 2 Door Stile may also be considered in securing the required percentage of cuttings in any given plank. (5) Each plank of No. 1 Shop Common shall contain not less than 50 per cent or more than 70 per cent of door cuttings of the sizes and grades herein mentioned.

No. 2 Shop Common—The sizes admissible in No. 2 Shop Common are: (1) Stiles in width 5 or 6 inches and from 6 ft., 8 in., to 7 ft., 6 in. in length. (2) Rails, 9 or 10 inches in width and from 2 ft., 4 in., to 3 ft., in length. (3) Top rails, 5 inches wide, and from 2 ft., 4 in., to 3 ft. in length. Top rails must however be of No. 1 Door Cuttings quality, but figured as No. 2 Door Cuttings. (4) Muntins, 5 inches wide and from 3 ft., 6 in., to 4 ft., in length. (5) Any number of cuttings of any one of the above sizes are admissible in the grade of No. 2 Shop Common. (6) Each plank of No. 2 Shop Common shall contain any one of the following: At least 25 per cent of No. 1 Door Cuttings, or not less than 40 per cent of all No. 2 Door Cuttings or not less than 33⅓ per cent No. 1 and No. 2 Door Cuttings combined.

1-inch Shop Common—Must be 5 inches and wider; not less than 15/16 thick in the rough. Must be of a cutting type to contain not less than 50 per cent nor more than 70 per cent of No. 1 or No. 2 clear cuttings ordinarily used in the manufacture of interior finish. Cuttings to be 5 inches and wider and 3 feet and longer.

All factory plank shall be graded from the poor side, and in determining the percentages of door cuttings, consideration must be given to the fact that plank are to be ripped full length in such manner as will yield the highest grade and largest percentage of door cuttings before cross-cutting, except in such cases where plank will yield a higher value by being first cross-cut for rails. In such instances as when stock is cross-cut for rails, where some of the stock so obtained is too poor for either No. 1 or No. 2 rails, and yet contains stiles or muntins, or top rails, which can be obtained by ripping this cross-cut stock, the door cuttings so obtained shall be figured in when determining percentages.

SIZES OF FIR FACTORY LUMBER

1-inch Shop Common S2S to 13/16-inch; 1¼-inch No. 1 Shop, S2S to 1 5/32-inches; 1½-inch No. 1 Shop, S2S to 1 13/32-inches; 2-inch No. 1 Shop, S2S to 1 25/32 inches; 2½-inch No. 1 Shop, S2S to 2 3/32-inches; 3-inch No. 1 Shop, S2S to 2 25/32-inches; 4-inch No. 1 Shop, S2S to 3 25/32 inches.

SHIP DECKING

Fir ship decking is graded No. 1 Clr. in accordance with the following specification (1917):

Flat sizes shall show edge grain on board face. Must be uniformly sawn and free from knots on face and upper half of calking edges, except will allow one small pitch pocket, not to exceed 2 inches in length in each 16 lineal feet; bright sap whether green or seasoned on face side corner, not exceeding one-fourth the width or one-third the length. One under side and lower half of calking edges, will allow sound and tight knots 1 inch or less in diameter and, or, small pitch pockets.

OTHER PRODUCTS

Other standard products manufactured include eave gutters, porch rails, newels, and porch columns.

CAR MATERIALS

Car materials are manufactured from select common and clear lumber stock under standard grading rules. The standard products are car decking or flooring, car sills, car siding and roofing, and car lining. Ordinarily, from 20 to 35 per cent of the cut is available for the manufacture of these products, but the exact amount made into them depends upon the demand.

These materials are graded to conform to the following rules and specifications where individual railroad specifications are not employed. (Issued Feb. 1915)

No. 2 Clear and Better V.G. 1x4&6 in. (Car Siding, Lining, etc.)—Angle of grain no less than 30 degrees. Will admit any three of the following defects or their equivalent of combined defects on the face side, based on 10 ft. lengths: slight torn grain, small pitch pockets that do not extend through the piece, sound pin knots. If specified S2S, rough spots on back side are permissible if the piece is of uniform thickness.

No. 2 Clear and Better F.G. 1x4&6 in. (Car Siding, Lining and Longitudinal Roofing, etc.)—Will admit any three of the following defects or their equivalent of combined defects on the face side, based on 10 ft. lengths: slight torn grain, small pitch pockets that do not extend through the piece, scab pitch pockets, sound pin knots, sound small knots or their equivalent of combined defects. If specified S2S, rough spots on back side permissible if the piece is of uniform thickness.

No. 2 Clear and Better, mill run as to grain.—Apply same rules as on flat grain and vertical grain.

Latitudinal roofing, 1x4&6 in.—Same as No. 2 Clear and Better V.G. and F.G., except will allow two defects for each 5 or 6 ft. in length.

No. 3 Clear 1x4&6 in. (Box Car Lining, etc.)—May be either flat or vertical grain. Red, yellow, or silver fir. Must be tight-knotted stock. Will admit of torn grain and may contain five pin or three small knots or one standard knot, or five small or two medium pitch pockets, which may extend through the piece, in any continuous five feet length of the piece or their equivalent of combined defects.

No. 2 Clear and Better V. G. 1½ and 2x6&8 in. (Car Decking, etc.)—Will admit any three of the following or their equivalent of combined defects on the face side: medium torn grain, medium pitch pockets that do not extend through the piece, sound small knots in a 9 or 10 ft. piece. Rough spots on the back side permissible if the piece is of uniform thickness. On D&M and shiplapped stock a $\frac{7}{16}$ inch or ½-inch tongue or lap may be ½ inch scant in width on occasional pieces.

No. 2 Clear and Better F.G. 1½ and 2x6&8 in. (Car Decking, etc.)—To be graded the same as V.G. except that scab pitch pockets will be admitted.

Select Common Decking—Will admit heavy torn grain, heart stain, any number of sound standard knots, or medium pitch pockets that do not extend through the piece, or any combination of the above with minor defects. On D&M and shiplapped stock a $\frac{7}{16}$-inch or ½-inch tongue or lap may be ⅛ inch scant in width on occasional pieces.

No. 1 Common Decking—Will admit heavy torn grain, any number of tight large knots, or medium pitch pockets that do not go through the piece, or minor defects. On D&M and shiplapped stock a $\frac{7}{16}$-inch or ½-inch tongue may be ⅛ inch scant in width on occasional pieces.

Car sills and framing are manufactured under No. 1 Common and Select Grades. Sills are manufactured in various sizes from 3¼ x 8¼ inches to 7 x 13 inches and in lengths from 34 to 60 feet in odd lengths.

Standard car decking or flooring is manufactured in three grades, 2 Clr. & Btr., Select Common and Common. It is cut to patterns tongued and grooved, or for splines as shown below. It is made either vertical grain or flat grain and in three widths, 2x6, 2x8, and 2x10 inches. Standard lengths are 9 and 10 feet and multiples of these lengths.

Standard fir car siding and roofing are manufactured in the grade of No. 2 Clr. & Btr. Standard sizes are 1x4, and 1x6 inches, with standard lengths of 8, 9, 10, and 12 ft., or multiples of these for siding, and 5 ft. or multiples for roofing.

These products are manufactured either vertical grain, flat grain, or a combination of both.

Car lining is manufactured to conform with specifications for No. 2 Clr. & Btr. and No. 3 Clr. car material, with both vertical and flat grain. Standard sizes are 1x4 and 1x6 inches in lengths of 8, 9, 10, 12, 14, 16, 18, and 20 feet or multiples.

COMMON BOARDS AND SHIPLAP

Common boards and shiplap are made from common lumber, of which from 60 to 80 per cent is obtained from an average run of logs. About 15 per cent of the common lumber is made into these forms. Boards are sold rough or surfaced on one or both faces and edges. Shiplap and D & M are made to pattern.

These products are manufactured in four grades, as follows (1917):

One-inch Selected Common—4 to 12-inch. Shall be square edged, well manufactured. Will admit sound and tight knots not over 1 inch in diameter in 4-inch and 6-inch; and not over 1½ inches diameter in 8-inch to 12-inch; and medium sized tight pitch pockets, not over 6 inches in length. These boards must be of a sound, strong character. A small amount of slightly stained sap admissible.

No. 1 Common—Will admit any two of the following or their equivalent of combined defects: Wane ½ inch deep on edge, 1 inch wide on face, extending not over one-sixth the length of the piece, sound and tight knots, approximately 1½ inches in diameter in 8 and 10-inch; 2½ inches in 12-inch; and not over 3 inches in diameter in widths over 12 inches; pitch pockets; seasoning checks; one straight split not longer than the width of the piece; sap stain. or a slight streak of heart stain. These boards must be firm and sound and suitable for use in ordinary construction without waste. Will allow a limited number of worm holes. Hemlock permitted in this grade.

No. 2 Common—Must be free from rot and will admit of large, coarse knots approximately 2 inches in diameter in 4 and 6-inch stock; 2½ inches in 8 and 10-inch; and one-third the width of the piece in 12-inch and wider;

spike knots; any amount of solid heart or sap stain; a limited number of well scattered worm holes; solid pitch or pitch pockets; small amount of fine shake; wane 2 inches wide, if it does not extend into the opposite face. A serious combination of above defects in any one piece not permitted. A board may have one large knot hole, provided piece is otherwise as good as No. 1 Common. Hemlock permitted.

No. 3 Common—Will admit of stock below the grade of No. 2 Common that is suitable for cheap sheathing and will allow large, coarse knots without restriction as to size; loose knots; unsound knots; knot holes; wane; splits; solid pitch; pitch pockets; shake; heart or sap stain; decayed streak; decayed sap; well scattered small rotten spots; any number of worm holes. A serious combination of above defects in any one piece not permitted. This grade shall be either Douglas fir, white fir, hemlock, larch or spruce or a combination of all.

Sizes of Boards and Shiplap and D. & M:

1x4-inch, 6-inch, 8-inch, 10-inch and 12-inch. Common Boards, S1S or S2S to ¾-inch. S1E or S2E ½-inch off. Shiplap 1x4-inch, 6-inch, 8-inch, 10-inch and 12-inch finished ¾x3, 5, 7, 9 and 11-inch face. D. & M. 1x4, 6, 8, 10 and 12-inch, finished size, ¾x3¼, 5⅛, 7, 9 and 11-inch face. Standard lengths are multiples of two feet.

General Specifications for Common Lumber:

Unless otherwise specified, discoloration through exposure to the elements shall not be considered a defect in the grades of Common if otherwise conforming to the grade called for.

In Selected Common and Common grades all Boards, Dimension, Joist and Timbers are sold subject to any natural shrinkage, whether shipped green, partially or wholly seasoned.

All Common lumber shipped rough must be well manufactured to sizes ordered. Occasional slight variation in sawing will be allowed.

In the following tables, No. 3 Common is omitted, since it forms but a small percentage of the one inch common.

APPROXIMATE PERCENTAGE OF ONE INCH COMMON MANUFACTURED INTO THE VARIOUS SIZES AND GRADES; ALSO PER CENT OF EACH SIZE BY GRADES

Size, Inches	Per cent, Index	Sel. Com.	Grades No. 1 Com.	No. 2 Com.	Totals
			Percentages		
1 x 4	All 1 in. Com.	0.2	2.9	0.6	3.7
	1 x 4 in.	6.2	78.9	14.9	100.0
1 x 6	All 1 in. Com.	0.2	7.5	3.4	11,1
	1 x 6 in.	1.6	67.5	30.9	100.0
1 x 8	All 1 in. Com.	0.1	31.7	9.7	41.5
	1 x 8 in.	0.2	76.4	23.4	100.0
1 x 10	All 1 in, Com.	0.2	13.9	6.0	20.1
	1 x 10 in.	0.8	69.2	30.0	100.0
1 x 12	All 1 in. Com.	0.4	14.4	8.8	23.6
	1 x 12 in.	1.9	60.9	37.2	100.0
Totals	All 1 in. Com.	1.1	70.4	28.5	100.0

1x2 and 1x3 inch Common Bds. are manufactured, but in too small quantities to appear in this table.

PERCENTAGE OF EACH LENGTH OF 1-INCH COMMON

Size, Inches	Grade	4	6	8	10	12	Lengths in Feet 14	16	18	20	22	All
							Percentages					
1 x 2	No. 1 Com.	.	.	.	28.1	29.7	20.6	19.1	2.5	.	.	100
1 x 3	No. 1 Com.	.	.	3.2	30.6	34.4	9.9	11.1	9.5	1.3	.	100
1 x 4	No. 1 Com.	1.0	4.4	11.6	17.3	22.4	16.0	20.1	6.2	1.0	.	100
	No. 2 Com.	0.5	4.6	10.1	14.0	18.0	10.0	25.6	16.5	0.7	.	100
1 x 6	No. 1 Com.	0.3	2.9	6.0	11.2	22.8	18.6	25.9	8.6	3.7	.	100
	No. 2 Com.	0.4	2.6	7.6	13.0	25.8	17.3	21.4	6.5	5.4	.	100
1 x 8	No. 1 Com.	0.1	3.2	5.1	12.9	27.6	20.4	21.7	6.0	2.4	0.6	100
	No. 2 Com.	0.9	1.7	6.1	12.2	29.3	18.6	20.7	7.6	2.9	.	100
1 x 10	No. 1 Com.	.	3.5	11.1	15.8	17.3	23.5	24.4	3.4	1.0	.	100
	No. 2 Com.	0.1	1.4	5.6	16.3	25.3	18.1	19.8	9.3	4.1	.	100
1 x 12	No. 1 Com.	.	1.1	3.1	13.4	21.5	18.2	31.6	7.4	3.7	.	100
	No. 2 Com.	.	1.4	4.2	12.7	27.8	18.0	21.2	9.6	5.0	0.1	100

Since Select Common stock is selected from No. 1 Com., percentages of each length are not available, but they are probably similar to the above.

COMMON DIMENSION

Common dimension lumber is manufactured from common lumber of all grades, and is one of the principal fir products. From 60 to 80 per cent of the lumber obtained from a normal run of Douglas fir logs is suitable for it. It is nominally 2 inches thick and from 3 to 20 inches wide, and is made in three grades as follows (1917):

Selected Common—Shall be sound, strong lumber, well manufactured and free from defects that materially impair the strength. Must be suitable for high class construction purposes and free from shake, loose or rotten knots. Will allow occasional variation in sawing; sound and tight, small, and standard knots and tight pitch pockets not over 6 inches in length. 12 inches and wider may contain, in addition to the above, a couple of large knots not to exceed 2 inches in diameter, when well placed. A slight amount of sap stain admissible.

No. 1 Common—Must be sound stock, well manufactured and suitable for all ordinary construction purposes without waste, and must be sound and tight-knotted stock. Will admit of coarser knots than 1-inch Common, which in a 2x4 and 3x4 may be approximately 1½ inches; 2 inches in 2x6 and 3x6; 2½ inches in 2x8 and 3x8 and 2x10 and 3x10; and ¼ the width of the piece in 12 inches and wider; spike knots that do not materially weaken the piece; wane not over ¼ the thickness of the piece. 1 inch wide on face up to 6 inches and 1½ inch wide on face on 8 inch and wider, extending not more than ⅓ the length of the piece or a proportionate amount for a shorter distance on both edges; stain; solid pitch; pitch pockets; seasoning checks; one straight split not more than the width of the piece; a limited number of worm holes and torn grain. A very serious combination of above defects must not be permitted in any one piece. Hemlock permitted in 4 and 6-inch widths.

No. 2 Common—This grade shall consist of lumber suitable for a cheaper class of construction than No. 1 Common. Will allow large, coarse knots, which in a 2x4 and 3x4 should not be larger than 2½ inches in diameter, 3 inches in 2x6 and 8 and 3x8 and 8, and ⅓ the width of the piece in diameter in 2x10 and 3x10 and wider; spike knots; an occasional knot hole if not too large; wane or decayed sap, leaving a fair nailing surface; heart and sap stain in any amount; small amount of fine shake; large pitch pockets; a few well scattered worm holes. A very serious combination of above defects must not be permitted in any one piece. Hemlock permitted in 4 and 6-inch widths.

Common dimension is most commonly sold S1S1E (surfaced one side and one edge). It is also sold rough, S1S, shiplap, and D. & M.

SIZE AND FORM OF 1" COMMON

Sizes, Inches	No. 1 Com.	Rgh.	S1S	Ship	D&M	No. 2 Com.	S1S	Ship
		Percent					Percent	
1 x 4	All No. 1 Com.	0.3	3.2	..	0.6	All No. 2 Com.	0.7	..
	No. 1 Com. 1"x4" ...	7.1	77.7	..	15.2	No. 2 Com. 1"x4" ..	100.0	..
1 x 6	All No. 1 Com.	2.6	7.4	0.1	1.3	All No. 2 Com.	4.1	7.8
	No. 1 Com. 1"x6" ...	23.0	64.4	1.1	11.5	No. 2 Com. 1"x6" ..	34.4	65.6
1 x 8	All No. 1 Com.	..	8.9	35.7	..	All No. 2 Com.	15.3	19.1
	No. 1 Com. 1"x8" ...	..	20.0	80.0	..	No. 2 Com. 1"x8" ..	44.6	55.4
1 x 10	All No. 1 Com.	0.1	11.2	8.3	..	All No. 2 Com.	13.8	7.8
	No. 1 Com. 1"x10" ..	0.7	57.2	42.1	..	No. 2 Com. 1"x10" .	63.8	36.2
1 x 12	All No. 1 Com.	1.3	19.0	..	..	All No. 2 Com.	31.4	..
	No. 1 Com. 1"x12" ..	6.4	93.6	..	..	No. 2 Com. 1"x12" .	100.0	..
Totals	All No. 1 Com.	4.3	49.7	44.1	1.9	All No. 2 Com.	65.3	34.7

No. 2 Common and No. 1 Common 1 x 8 inch are sold rough but in quantities too small to show in this table.

APPROXIMATE PERCENTAGE OF COMMON DIMENSION MANUFACTURED INTO THE VARIOUS SIZES AND GRADES; ALSO PER CENT OF EACH SIZE BY GRADES

Size, Inches	Per cent Index	Sel. Com	No. 1 Com	No. 2 Com	Totals
2 x 2	% All 2 in. Com.	..	0.2	..	0.2
	% 2 x 2 in.	..	100.0	..	100.0
2 x 4	% All 2 in. Com.	0.1	36.2	3.6	39.9
	% 2 x 4 in.	0.3	90.7	9.0	100.0
2 x 6	% All 2 in. Com.	0.1	29.6	1.9	31.6
	% 2 x 6 in.	0.2	93.8	6.0	100.0
2 x 8	% All 2 in. Com.	0.1	12.2	0.1	12.4
	% 2 x 8 in.	0.7	98.4	0.9	100.0
2 x 10	% All 2 in. Com.	..	6.5	..	6.5
	% 2 x 10 in.	..	100.0	..	100.0
2 x 12	% All 2 in. Com.	0.1	8.5	0.1	8.7
	% 2 x 12 in.	0.5	98.0	1.5	100.0
2 x 14	% All 2 in. Com.	..	0.7	..	0.7
	% 2 x 14 in.	..	100.0	..	100.0
Total	% All 2 in. Com.	0.4	93.9	5.7	100.0

No. 3 Common, when manufactured, forms from 0.1 to 2.5 per cent of this product and is chiefly 2 x 4, 2 x 6, 2 x 8, and 2 x 10 inches. It is cut into lengths of from 6 to 40 feet in multiples of two feet.

PERCENTAGE OF EACH LENGTH OF COMMON DIMENSION

Size, Inches	Grade	6	8	10	12	14	16	18	20	22
						Percentages				
2 x 4	Sel. Com.	..	13.9	2.6	9.8	21.1	52.6	..	..	..
2 x 6	Sel. Com.	..	..	0.8	28.5	18.0	40.4	1.5	1.7	..
2 x 8	Sel. Com.	..	..	..	11.6	22.3	42.8	2.3	9.0	..
2 x 10	Sel. Com.	..	..	..	9.7	17.2	69.6	..	..	..
2 x 12	Sel. Com.	..	..	1.5	19.6	32.4	43.8	..	2.7	..
2 x 2	No. 1 Com.	..	..	3.6	23.0	17.8	55.6	..	..	..
2 x 4	No. 1 Com.	0.3	3.1	6.0	17.8	16.9	32.0	16.0	6.7	0.4
2 x 6	No. 1 Com.	..	0.6	4.2	15.0	16.6	30.3	12.6	11.3	3.0
2 x 8	No. 1 Com.	..	0.1	1.2	15.9	20.1	30.7	10.5	10.5	2.2
2 x 10	No. 1 Com.	..	0.1	1.8	15.7	18.2	30.3	10.6	10.2	1.4
2 x 12	No. 1 Com.	..	0.1	1.8	17.2	16.6	41.6	8.5	7.6	1.7
2 x 14	No. 1 Com.	..	..	3.9	4.9	3.4	9.9	6.9	3.1	13.6

Size, Inches	Grade	24	26	28	30	32	34	36	38
				Percentages					
2 x 4	Sel. Com.	..	..	..	..	..	..	..	..
2 x 6	Sel. Com.	9.1	..	..	..	..	..	..	..
2 x 8	Sel. Com.	8.5	..	3.1	..	..	..	0.4	..
2 x 10	Sel. Com.	1.7	1.8	..	..	..	..	..	..
2 x 12	Sel. Com.	..	..	..	..	..	..	..	..
2 x 2	No. 1 Com.	..	..	..	..	..	..	..	..
2 x 4	No. 1 Com.	0.7	0.1	..	..	..	..	..	..
2 x 6	No. 1 Com.	4.5	1.4	0.2	0.2	0.1	..	..	..
2 x 8	No. 1 Com.	5.4	1.6	1.1	0.2	0.3	0.1	0.1	..
2 x 10	No. 1 Com.	3.1	1.8	0.5	0.4	5.5	0.1	0.1	0.2
2 x 12	No. 1 Com.	1.5	2.3	0.5	0.4	0.2	..	..	..
2 x 14	No. 1 Com.	33.0	14.9	3.4	1.5	1.5	..	..	..

SIZE AND FORM OF COMMON DIMENSION

Size, Inches	S4S	S1S	D&M	S1S1E	Rough	Total
			Percentages			
2 x 2	2.7	..	..	97.3	..	100.0
2 x 4	0.8	0.1	1.0	95.1	3.0	100.0
2 x 6	0.1	..	..	99.4	0.5	100.0
2 x 8	..	..	..	99.7	0.3	100.0
2 x 10	..	..	..	98.7	1.3	100.0
2 x 12	0.1	0.1	..	90.5	9.3	100.0
2 x 14	..	..	..	100.0	..	100.0
2 x 16	..	..	..	100.0	..	100.0
All	..	..	..	98.9	1.1	100.0

COMMON PLANK AND SMALL TIMBERS

Common plank and small timbers are manufactured from all grades of common lumber. About 10 per cent of the common lumber is ordinarily cut into them. The three grades are the same as those for common dimension. These products are sold rough, S1S1E, S2S, and S1S.

The dimensions into which this material is cut run from 3x3 to 8x8 inches, with widths from 3 to 20 inches in the 3 inch and 4 inch stock. Stock is not made 5 inches and 7 inches; and with the exception of 3 inch widths, all width measurements are even inches. The products are made

in even lengths from 8 to 40 feet inclusive. Sizes 6x6, 6x8, and 8x8 inches, when over 40 feet in length, are classed as "timbers" instead of "small timbers."

Sizes of Dimension Plank and Small Timbers

S1S1E or S4S; 2x4 to 1⅝x3⅝; 2x6 to 1⅝x5⅝; 2x8 to 1⅝x7½; 2x10 to 1⅝x9½; 2x12 to 1⅝x11½; 2x14 to 1⅝x13½; 2x16 to 1⅝x15½; etc. 3x4 to 2½x3⅝; 3x6 to 2½x5½; 3x8 to 2½x7½; 3x10 to 2½x9½; 3x12 to 2½x11½; 3x14 to 2½x13½; 3x16 to 2½x15½, etc.; 4x4 to 3½x3½; 4x6 to 3½x5½, etc.; 5x5 to 4½x4½, etc.; 6x6 and 8, ½" off each way.

APPROXIMATE PERCENTAGE OF No. 1 COMMON PLANK AND SMALL TIMBERS MANUFACTURED INTO THE VARIOUS FORMS AND SIZES

Size, Inches	Per cent Index	S4S	S1S1E	Rough	Total each dimension
3 x 4	Per cent Total	0.0	..	0.3	0.3
	Per cent 3 x 4 inches	10.9	..	89.1	100.0
3 x 6	Per cent Total	..	..	0.2	0.2
	Per cent 3 x 6 inches	..	..	100.0	100.0
3 x 8	Per cent Total	..	1.9	1.2	3.1
	Per cent 3 x 8 inches	..	60.9	39.1	100.0
3 x 10	Per cent Total	..	2.7	2.4	5.1
	Per cent 3 x 10 inches	..	52.1	47.9	100.0
3 x 12	Per cent Total	..	12.6	14.2	26.8
	Per cent 3 x 12 inches	..	46.9	53.1	100.0
4 x 4	Per cent Total	1.3	8.1	2.3	11.7
	Per cent 4 x 4 inches	11.1	69.6	19.3	100.0
4 x 6	Per cent Total	0.5	16.1	2.1	18.7
	Per cent 4 x 6 inches	2.4	86.4	11.2	100.0
4 x 8	Per cent Total	..	..	0.1	0.1
	Per cent 4 x 8 inches	..	..	100.0	100.0
4 x 10	Per cent Total	..	..	0.7	0.7
	Per cent 4 x 10 inches	..	1.9	98.1	100.0
4 x 12	Per cent Total	..	..	3.8	3.8
	Per cent 4 x 12 inches	..	..	100.0	100.0
6 x 6	Per cent Total	0.7	18.7	3.0	22.4
	Per cent 6 x 6 inches	3.2	83.5	13.3	100.0
6 x 8	Per cent Total	0.5	3.9	0.9	5.3
	Per cent 6 x 8 inches	9.3	74.3	16.4	100.0
8 x 8	Per cent Total	1.3	0.5	..	1.8
	Per cent 8 x 8 inches	74.0	26.0	..	100.0
Total	Per cent Total	4.3	64.5	31.2	100.0

No. 2 and No. 3 Common are manufactured in amounts too small to appear in the above figures, but when manufactured occur among the various sizes and lengths in approximately the same proportions as No. 1 Common.

PER CENT OF EACH LENGTH OF PLANK AND SMALL TIMBERS

Size	Dressing	8	10	12	14	16	18	20	22	24
		Length in Feet								
		Percentages								
3x 8	S1S1E	..	13.7	12.1	..	39.9	34.3	..	..	..
3x10	S1S1E	..	8.0	6.9	2.4	10.9	61.1	..	..	10.7
3x12	S1S1E	..	1,3	6.7	9.4	34.4	29.2	8.5	0.3	8.0
3x12	Rough	1.1	0.1	5.6	4.5	71.0	9.5	4.8	1.5	0.7
4x 4	S4S	0.1	2.9	21.2	16.4	27.9	8.9	12.8	0.5	2.3
4x 4	S1S1E	..	4.3	24.4	14.9	31.8	6.5	9.9	..	2.9
4x 4	Rough	..	0.3	26.1	19.3	41.3	5.6	6.1	0.9	..
4x 6	S4S	0.2	0.9	10.6	13.4	27.2	15.2	13.4	2.4	6.5
4x 6	S1S1E	..	0.2	10.4	12.9	24.8	20.2	16.3	1.5	7.4
4x 6	Rough	..	1.0	11.7	21.4	29.1	15.7	20.5	0.6	..
4x12	Rough	..	..	..	..	2.7	54.2	2.4	5.9	33.7
6x 6	S4S	0.2	0.4	8.1	10.3	24.5	14.3	13.5	4.0	7.5
6x 6	S1S1E	0.1	0.2	5.4	9.0	29.1	12.2	11.9	2.5	14.1
6x 6	Rough	..	1.5	10.8	12.4	32.1	17.9	8.9	2.1	10.6
6x 8	S4S	0.2	0.3	7.2	11.8	23.2	13.2	12.8	3.8	8.4
6x 8	S1S1E	..	..	7.2	12.2	32.6	15.4	16.8	3.3	13.0
6x 8	Rough	..	..	11.0	18.9	18.0	18.4	3.7	..	2.9
6x10	S1S1E	..	4.5	1.3	25.1	34.0	10.1	8.9	..	16.1
6x12	Rough	..	..	..	..	..	25.3	56.2	..	5.0
8x 8	S4S	1.6	3.1	9.0	10.7	30.4	14.6	14.7	1.4	1.9
8x 8	Rough	..	0.3	12.5	11.9	2.1	..	..	..	19.6

Size	Dressing	Length in Feet 26	28	30	32	34	36	38	40
		Percentages							
3x 8	S1S1E	..	..	..	..	..	..	..	..
3x10	S1S1E	..	..	..	..	..	..	..	..
3x12	S1S1E	..	..	..	2.0	..	0.2	..	..
3x12	Rough	0.6	..	..	0.5	..	..	..	..
4x 4	S4S	0.1	0.2	0.1	6.6	..	..	..	..
4x 4	S1S1E	..	2.9	0.8	2.1	..	..	..	..
4x 4	Rough	..	0.4	..	..	..	..	..	..
4x 6	S4S	1.3	1.2	0.5	7.2	..	..	..	..
4x 6	S1S1E	3.7	1.4	1.0	0.2	..	..	..	..
4x 6	Rough	..	..	..	..	..	..	..	..
4x12	Rough	..	..	..	..	..	..	..	..
6x 6	S4S	3.1	1.7	0.8	11.2	..	0.3	..	0.1
6x 6	S1S1E	5.9	5.1	1.7	2.8	..	..	..	..
6x 6	Rough	2.4	..	..	..	..	..	..	..
6x 8	S4S	3.8	2.9	2.1	9.1	0.7	0.3	..	0.2
6x 8	S1S1E	..	..	..	..	..	..	..	..
6x 8	Rough	19.2	..	..	7.9	..	..	..	..
6x10	S1S1E	..	..	..	..	..	..	..	..
6x12	Rough	..	..	..	13.5	..	..	..	..
8x 8	S4S	1.4	2.6	1.8	2.9	..	..	..	3.9
8x 8	Rough	28.3	16.4	..	..	8.9	..	..	..

Note.—These figures are applicable to No. 1, No. 2, and No. 3 Common lumber of these dimensions.

TIMBERS

Timbers include the larger pieces of common stock from 8x8 to 24x24 inches in squared and rectangular pieces. When 6x6 to 6x10 inch pieces are over 40 feet in length, they are also sold as timbers. Timbers are made from common lumber stock, from 30 to 60 per cent of the material from ordinary fir logs being suitable. Normally about 10 per cent of the common lumber is made into timbers. The amount manufactured into large timbers varies greatly in different mills, owing to the kind of orders handled, the mill practice as regards products specialized upon, and the character of the logs cut. There are three grades of timber, as follows (1917):

Selected Common—Shall be sound, strong timber, well manufactured and free from defects that materially impair its strength. Must be suitable for high class construction purposes; free from shake, splits, loose or rotten knots. Will allow sound and tight knots, if not in clusters, and which in no case shall exceed in diameter, one-sixth the width of the face in which such knots occur up to and including 12x12; and further providing that such sound and tight knots in 14x14 and larger, shall in no case exceed two and a half inches in diameter. The select common grade also will allow occasional variation in sawing; tight pitch pockets, not over six inches in length; wane not to exceed one inch on one corner and not exceeding one-sixth the length of the piece.

No. 1 Common—Timber 6x10 and larger shall be sound stock well manfactured and free from defects that will materially weaken the piece. Occasional slight variation in sawing allowed. 10x10 timbers may have a 2-inch wane on one corner or the equivalent on two or more corners; checks and season checks not extending over ⅛ the length of the piece. Smaller and larger timbers may have wane in proportion. In addition will allow large, sound and tight knots which, approximately, should not be more than one-fourth the width in diameter of any one side in which they may appear; spike knots; stained sap one-third the width and slight streak of heart stain extending not more than ¼ the length of the piece.

No. 2 Common—This grade will admit large, loose or rotten knots; a 10x10 may have 3-inch wane on one corner or the equivalent on two or more corners,—larger and smaller sizes in proportion;—shake or rot that does not impair its utility for temporary work. Hemlock and White Fir will be allowed in this grade.

Sizes of Fir Timbers

Sizes—S1S, S1E, S1S1E, or S4S; 8x8 and larger ½ inch off each way. Standard lengths are multiples of two feet.

A lower grade of timbers than No. 2 Common is manufactured for use in mining construction and is graded as follows (1917):

No. 1—This grade shall consist of lumber free from serious shake, splits or rot. Will allow variations in sawing, sap stain, solid heart stain extending over not more than half of piece; large knots; a few well scattered worm holes, and wane 3 inches on one corner or its equivalent on two or more corners. Will admit 15% Hemlock.

Timbers are cut into even lengths from 8 to 40 feet, and for special orders in lengths up to 90 feet, at additional cost. From seventy to ninety per cent of the timbers are sold rough.

PERCENTAGES OF EACH LENGTH AND SIZE OF TIMBERS

Size,	Lengths in Feet 8	10	12	14	16	18	20	22	24	26	28	30	32
	Percentages												
6x10	..	2.2	1.1	11.9	21.9	3.9	3.5	3.3	6.0	4.6	..	..	32.3
6x12	..	..	..	..	1.6	24.2	50.7	3.0	6.5	..	..	..	12.9
8x10	4.8	9.3	11.8	7.9	8.7	2.2	12.2	5.3	4.3	1.0	1.4	1.0	12.7
10x10	..	1.1	28.1	9.0	18.2	5.6	3.7	0.9	10.2	0.4	0.8	3.3	5.3
10x12	..	4.4	6.7	2.8	5.7	15.0	15.6	..	3.8	..	2.2	13.1	12.7
12x12	..	0.6	5.6	4.8	6.1	3.9	6.9	0.3	19.4	2.2	3.0	2.1	7.9
12x14	..	16.6	10.0	3.9	8.9	4.0	5.0	12.2	6.7	14.4	18.3	..	..
12x16	..	4.4	16.4	31.1	10.2	5.2	14.7	6.5	5.0	6.5	..	..	..

Size	Lengths in Feet 34	36	38	40	42	44	46	48	Lengths % all	Timbers % of all
	Percentages									
6x10	..	..	..	9.3	..	..	..	..	100.0	4.0
6x12	1.1	..	..	..	..	..	..	..	100.0	6.0
8x10	16.2	..	..	1.2	..	..	..	..	100.0	4.0
10x10	3.3	3.5	1.1	2.3	..	0.6	1.3	1.3	100.0	19.0
10x12	1.3	2.9	..	10.0	..	..	..	3.8	100.0	8.0
12x12	0.2	14.0	2.4	18.6	1.2	..	..	0.8	100.0	54.0
12x14	..	..	..	..	..	..	..	..	100.0	2.0
12x16	..	..	..	..	..	..	..	..	100.0	3.0

Note.—The blanks do not indicate that no timbers are made in such sizes, but that the amount was too small to be shown in per cent.

STRINGERS

Bridge stringers are cut into dimensions of 6 to 10x16 inches and 6 to 10x18 inches and in lengths from 14 feet upward in multiples of two feet. They are cut to two grades, as follows (1917):

Select Common—Sap shall not show on any one corner more than 10% of any one side or edge measured across the surface anywhere along the length of the piece. Shall be free from shake, splits or pitch pockets, over ⅝ inches wide or 5 inches long. Knots greater than two inches in diameter will not be permitted within one-fourth of the depth of the stringer from any corner nor upon the edge of the piece; knots shall in no case exceed three inches in diameter.

Common—shall be sound common lumber, free from large, unsound knots or knots in clusters, or other defects that will materially unfit the piece for the purpose intended.

Stringers are sold rough, S1S1E, and S4S. The most common sizes and lengths sold are 8x16 and 9x18 inches and 14, 16, 18, 28 and 32 feet. From 80 to 90 per cent of all stringers manufactured are 8x16 inches.

TIES

At an average plant 7 per cent of the common lumber is cut into ties.

Ties are made to two grade specifications, No. 1 Common and No. 2 Common. The grade specifications agree generally with those for similar grades for planks and small timbers. Ties are sawed to the dimensions 6x8, 6x9, 7x8, and 7x9 inches. They are ordinarily 8 feet long, though railroad companies have a variety of individual specifications, to which orders are especially cut. Typical specifications for cross ties, bridge ties, and switch ties are as follows (1917):

Cross Ties—Square sawed ties of Class No. 1 shall be of red or yellow fir exactly (8) feet long, with ends sawed off square. They shall be seven (7) inches thick by nine (9) inches wide. They shall be made from good, sound, live, straight grained timber, and shall be free from splits, shakes or large pitch seams and pitch pockets, or large black or unsound knots, or wane edges over one (1) inch on the face. Sound knots will be admitted, not to exceed two and one-half (2½) inches in diameter.

Ties made from smooth barked, coarse grained, second growth fir timber or from coarse grained hearts of large logs will not be accepted.

No split ties accepted.

Ties made from fire killed timber that is worm eaten will not be accepted.

Ties varying one (1) inch or more under or over eight (8) feet long will not be accepted (1917).

Bridge Ties—Must be cut from good, sound, live, straight and close grained yellow or red fir, cut free from wane edges, square and true to sizes ordered, and must be free from large, loose or unsound knots, shakes, splits, or large pitch seams or pitch pockets and knots in clusters, and must not show a sap angle on more than one edge of a stick. Subject to inspection before loading.

Fir Switch Ties—Timber must be sound yellow or red fir, cut from live trees, free from large or unsound knots, large shake or pitch seams over 6 to 8 inches in length and wane edges over 1 inch on the face, or other defects which would impair its strength or durability, and must be sawed true to dimensions called for above. Ends to be cut off square. To be delivered in complete sets f.o.b. cars on line of......................Ry., subject to inspection before loading.

WEIGHT OF FIR LUMBER PRODUCTS

An important item to every manufacturer is the weight of his product, since most prices are quoted f.o.b. destination, and proper allowance must be made for freight. Lumber is different from many other manufactured products because its weight is not uniform for a given bulk, neither does it remain constant for any length of time, owing to its tendency to give off or take up moisture.

ACTUAL WEIGHTS OF DOUGLAS FIR LUMBER PRODUCTS

Product	Per Cent of Machined Cross Section to Rough Green Cross Section	Weight Per Thousand Board Feet: Green 38 lbs. per cu. ft. 32% moisture	Air Dry (Winter) 34 lbs. per cu. ft. 18% moisture	Air Dry (Summer) 32 lbs. per cu. ft. 12% moisture	Kiln Dry 31 lbs. per cu. ft. 8% moisture
1 x 4 Flooring V.G. & F.G.	67.1	2,125	1,900	1,790	1,790
1 x 6 Flooring F.G.	62.8	1,990	1,780	1,675	1,675
1 x 6 Flooring V.G.	68.7	2,175	1,945	1,830	1,830
⅝ x 4 Ceiling	70.2	1,400	1,255	1,180	1,180
⅝ x 4 Partition	68.0	1,345	1,205	1,135	1,135
1 x 4 D.V. Ceiling	56.0	1,775	1,585	1,490	1,490
2 x 6 Silo Staves	71.7	2,270	2,030	1,910	1,910
1 x 6 Finish	68.5	2,170	1,940	1,825	1,825
1 x 8 Finish	68.0	2,150	1,925	1,810	1,810
1 x 12 Finish	69.3	2,190	1,960	1,845	1,845
1 x 6 Drop Siding & Rustic	60.25	1,910	1,705	1,605	1,605
1 x 8 Rustic	63.2	2,000	1,790	1,685	[1] 1,685
2 x 4 S1S1E	73.6	2,330	2,085	1,965	1,900
2 x 6 S1S1E	76.2	2,410	2,155	2,030	1,965
2 x 8 S1S1E	76.2	2,410	2,155	2,030	1,965
2 x 10 S1S1E	77.2	2,440	2,185	2,055	1,990
2 x 12 S1S1E	77.9	2,530	2,260	2,130	2,060
1 x 6 S1S	75.0	2,375	2,120	2,000	1,935
1 x 8 S1S	75.0	2,375	2,120	2,000	1,935
1 x 10 S1S	75.0	2,375	2,120	2,000	1,935
1 x 12 S1S	75.0	2,375	2,120	2,000	1,935
1 x 8 Shiplap	65.6	2,080	1,860	1,750	1,695
1 x 10 Shiplap	67.5	2,135	1,910	1,800	1,740
1 x 12 Shiplap	68.8	2,180	1,950	1,835	1,775
3 x 12 S1S1E	79.9	2,530	2,260	2,130	2,060
4 x 6 S1S1E	80.3	2,540	2,270	2,140	2,070
6 x 6 S1S1E	84.0	2,660	2,380	2,240	...
6 x 8 S1S1E	86.0	2,720	2,435	2,290	...
8 x 8 S4S	87.8	2,780	2,485	2,340	...
10 x 10 S4S	90.2	2,855	2,550	2,405	...
12 x 12 S4S	92.0	2,910	2,610	2,450	...
8 x 16 S4S	91.0	2,880	2,580	2,430	...

[1] Above this point a kiln dry weight of 32 lbs. per cubic foot is used because the density of the wood is increased by shrinkage prior to machining. The other products are figured as being machined green.

Note.—The above weights are correct for the average run of fir shipped under the moisture conditions specified and are obtained by operators striving for low weights. The density or weight of fir varies, and, in addition, much lumber is shipped with more moisture than that shown above. For these reasons the weight figures are only indicative of results that can be obtained.

This variance in weight has made it necessary to establish arbitrary weights for use in figuring freight on quotations, and the figures were made sufficiently high to protect most of the manufacturers against loss through extra freight.

The weights shown in the table are not the arbitrary shipping weights ordinarily used in calculating freight, but they are the actual weight of properly dried products made from wood of average density.